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Final Report

SINSS Ice Navigation Console Phase II: Console Implementation and Bridge Upgrade

November 1989

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16. Abstract

This report describes the implementation of the bridge upgrade, as designed in the SINSS Console Re-Design Phase I project. The objective of this project was the installation of the new SINSS and navigation consoles on the bridge of the M.V. Arctic. Advantage was taken of a scheduled drydocking period, to implement the upgrade in the most adequate conditions. The bridge upgrade was undertaken in Malta during the months of January and February of 1989, and all of the necessary material was shipped on location from Canada. Substantial difficulties were experienced during the shipping of material to Malta.

In addition to the replacement of the bridge consoles and the rearrangement of the layout of the bridge, an information display system was developed to assist the navigators at the wing consoles. Modifications were required to the resident instrumentation system to allow the transfer of information to the wing console information display system. An interface was developed from the IBM PC compatible system to the resident Hewlett Packard system.

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16. Résumé

Ce rapport décrit la mise en place des nouvelles consoles, conformément à la phase I du projet de modernisation de la console du système auxiliaire embarqué de navigation dans les glaces (SINSS). Ce projet visait l'installation de nouvelles consoles de navigation et du SINSS sur la passerelle du N.M. ARCTIC. Cette modernisation a été réalisée à l'île de Malte lors d'une mise en cale sèche prévue en janvier et février 1989. Tout le matériel nécessaire a été expédié sur place à partir du Canada. Le transport du matériel d'ici au continent européen a donné lieu à de nombreux problèmes.

En plus de remplacer les consoles et de réaménager la passerelle, un système d'affichage a été mis au point pour faciliter la tâche des navigateurs aux consoles périphériques. On a donc modifié en conséquence le systèm d'instrumentation en place pour permettre le transfert de l'information au système d'affichage de l'information sur les consoles périphériques. Une interface dédiée a été réalisée entre la système IBM compatible et le système Hewlett Packard en place.

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We would like to thank Captain David Millar and the officers of the M.V. Arctic, for their patience in dealing with the inconveniences created by the upgrade.

Special thanks to Canarctic's personnel that helped to solve problems during the shipment of the equipment to Malta.

This report was authored by Charles Gautier with editorial review provided by Alan R. Sneyd.

Executive Summary

This report describes the implementation of the SINSS and navigation consoles, and the upgrade of the bridge of the M.V. Arctic. The upgrade and console implementation follow from their initial design in phase I of this project, entitled "SINSS Console Re-Design". The navigation consoles and the SINSS console were fabricated in Canada during the months of October, November, and December of 1988. A scheduled drydock period was chosen as the most appropriate time for the installation. Several shipyards were consulted and the Malta drydock was selected in December as the implementation site. Substantial shipment problems were experienced during delivery of the equipment to Malta.

The ship entered the drydock in early January and remained in Malta for a total of 20 days. The old consoles were dismantled and removed and all the components to be reused in the new consoles were put aside. The deck surfaces were prepared in way of the new consoles, new mounting bases were installed and cable penetrations were made as needed. The new consoles were brought into position and securely fastened. Old and new components were installed in the consoles and new electrical cables were installed as required to complete the interconsole circuitry. The console components were connected and systems were tested with satisfactory results.

The new SINSS console was fastened in position and ice navigation components mounted inside. All SINSS related cables were routed, including a variety of spare cables to facilitate future installations or modifications. All bridge systems were tested and found to function normally.

The introduction of the new navigating and SINSS consoles in the bridge environment prompted the redesign of all auxiliary areas of the bridge. The auxiliary areas include the research area, the pantry and the main navigation chart table. A new desk and chart table were installed in the research area to help support ice navigation and future research opportunities. The height of the chart table instrument panel was reduced to allow for an unobstructed view from behind the table. In order to reduce the height, the instrument panel was redesigned. Obsolete instruments were removed and the remaining equipment was arranged to promote easy access and optimum functional grouping. The pantry area was redesigned to maximize storage space and include a sink and water fountain, features that were not present in the past.

The new wing console incorporates an information display monitor. A computer system was installed to drive the information display monitor. The information display computer utilises the ship's VSPMS (Vessel Safety and Performance Monitoring System) to supply information on safety and performance parameters. An interface was developed to transfer the information from the ship's VSPMS system to the wing console information display computer. The driving software for the information display system was developed and the resident instrumentation system was modified to send the necessary information to the display system.

S O M M A I R E

Ce rapport concerne la mise en place des consoles de navigation et du SINSS et le réaménagement de la passerelle du N.M. Arctic. Le réaménagement de la passerelle et l'installation des consoles s'inscrivaient dans le cadre de la phase I du projet "SINSS Console Re-Design". Les consoles de navigation et du SINSS ont été fabriquées au Canada au cours des mois d'octobre, novembre et décembre 1988. Il a été décidé qu'une mise en cale sèche programmée serait le moment opportun de procéder à l'installation des consoles. Après consultation auprès de plusieurs chantiers navals, c'est celui de l'île de Malte qui a été choisi comme point d'installation, en décembre. Des problèmes importants ont été rencontrés pendant l'expédition du matériel vers l'île de Malte.

Le navire est entré au chantier naval au début de mois du janvier et est demeuré dans l'île de Malte pendant 20 jours. Les consoles en place ont d'abord été démontées et enlevées, et l'on a pris soin de mettre de côté les éléments devant servir dans les nouvelles consoles. La mise en place de celles-ci a nécessité la mise à nu des platelages du pont, l'installation de nouveaux supports et le découpage des entrées de câblage nécessaires. Les nouvelles consoles ont été mises en place et fixées solidement aux supports. Les composants nouveaux et récupérés ont été montés dans les consoles, et on a installé le nouveau câblage électrique afin de compléter les circuits interconsoles. Ensuite, on a procédé au branchement des consoles; la mise à l'essai des systèmes a donné des résultats satisfaisants.

La nouvelle console SINSS a été mise en place, et les éléments nécessaires à la navigation dans les glaces y ont été incorporés. Tout le câblage nécessaire à la console SINSS a été installé ainsi qu'une variété d'autres câbles afin de permettre des installations et des modifications futures. Tous les systèmes de la passerelle ont été mis à l'essai, et leur fonctionnement a été jugé normal.

La mise en place des nouvelles consoles de navigation et du SINSS a nécessité le réaménagement des postes auxiliaires sur la passerelle, c'est-à-dire l'aire de recherche, le coin repas et la table principale des cartes. Dans l'aire de recherche, on a installé un nouveau bureau et une nouvelle table des cartes pour faciliter la navigation dans les glaces et l'exécution de nouvelles activités de recherche. On a également abaissé le panneau d'instrumentation adjacent à la table des cartes pour dégager la vue de celui qui se trouve à cette table. Pour ce faire, on a dû redessiner le panneau d'instrumentation. Les instruments désuets ont été retirés et le matériel réaménagé pour le rendre plus facile d'accès et ainsi obtenir une utilisation plus fonctionnelle. On a également réaménagé le coin repas pour augmenter l'espace de rangement et y ajouter un évier et une fontaine.

La nouvelle console périphérique comprend un écran d'affichage commandé par un ordinateur installé à cette fin. Cet ordinateur puise les paramètres de sécurité et de performance dans les données du système VSPMS du navire (système de surveillance - sécurité et performances). Le transfert de l'information d'un système à l'autre s'effectue au moyen d'une interface conçue à cette fin. Le logiciel de commande du système d'affichage a été mis au point et le système d'instrumentation modifié pour permettre de transférer l'information nécessaire au système d'affichage.

Table of Contents

	Page
1. Introduction	1
2. Overall Objectives	3
2.1 Specific Objectives:	3
3. Bridge Design	4
3.1 SINSS Definition	5
3.2 Bridge Layout	6
3.2.1 Front Console Location	11
3.2.2 Auxiliary Console Location	13
3.2.3 Radar Display Locations	19
3.2.4 SINSS Console Location	20
3.3 SINSS Console Design	24
3.3.1 Console Requirements	24
3.3.2 SINSS Components Description	25
3.3.3 SINSS Console Layout	31
3.4 Navigating Console Design	33
3.4.1 Functional Distribution of Bridge Components	33
3.4.2 Front Console Profile	34
3.4.3 Component Selection	50
3.5 Chart Table Modifications	51
3.6 Auxiliary Areas	52
3.6.1 Pantry Area	52
3.6.2 Research Area	53
3.7 Electrical	53
3.8 Wing Console Information Display System	56
3.8.1 Ice Navigation Page	57
3.8.2 Open Water Navigation Page	58
3.8.3 Manoeuvring Page	62

Page

4. **Implementation** 64
   4.1 Shipyard Selection 65
   4.2 Material Shipment 67
   4.3 Bridge Implementation 68
   4.4 WCIDS Implementation 74
      4.4.1 VSPMS Software Modifications 74
      4.4.2 System Implementation 75

5. **Conclusions** 76

6. **Recommendations** 80

References 81

Appendices

Appendix A - M.V. Arctic Vessel Safety and Performance Monitoring System Basic Code Listing (Under separate cover, one copy available only)

Appendix B - VSPMS Pascal Code Source Listing (Under separate cover, one copy available only)

Appendix C - Wing Console Information Display System "C" Language Program Listing (Under separate cover, one copy available only)

Appendix D - Vessel Safety and Performance Monitoring System Description

Appendix E - Photographic Record (Under separate cover, one copy available only.)

Appendix F - Technical Drawings (Under separate cover, one copy available only.)

List of Figures and Tables

Figure No.	Description	Page
1	Main Bridge Layout Prior to Implementation	7
2	Main Bridge Layout After Upgrade	9
3	Phase I Bridge Layout	15
4A	Phase I Auxiliary Console Design	17
4B	Phase I Auxiliary Console - Component Layout ..	18
5	Arctic Marine Radar Component Layout	21
6	SINSS Ice Navigation Console	27
7	Wing Console Layout	37
8	Main Console Layout	41
9	Auxiliary Console Layout	45
10	Navigation Console Profile	47
11	Ice Navigation Page	59
12	Open Water Navigation Page	59
13	Manoeuvring Page	63
14	Old Chart Table	70
15	Old SINSS Console	70
16	Old Pantry Area	71
17	New Chart Table	71
18	New SINSS Console	72
19	New Main Console	72
20	New Bridge Front	73
21	New Pantry Area	73

Table No.	Description	Page
1	SINSS Console Components List	26
2	Wing Console Component Lists	35
3	Main Console Component Lists	39
4	Auxiliary Console Components List	43

SINSS Ice Navigation Console
Phase II: Console Implementation and Bridge Upgrade

1. Introduction

The development, by Canarctic, of a shipboard ice navigation system occurred over several years and culminated with the specification of a first generation SINSS system in 1987. It was recognized that in order for SINSS to be used operationally onboard the M.V. Arctic, the various information displays needed to be arranged in a unified console. The purpose of the SINSS ice navigation console project was to develop the design of the SINSS console (Phase I) and to build and install the unit onboard the M.V. Arctic (Phase II).

The introduction of the SINSS console represents a significant addition to the bridge of the M.V. Arctic. The impact on the bridge was sufficient to warrant a complete re-design of the bridge, to bring all consoles to a similar standard as the SINSS console. Canarctic's experience has been that the original layout of the bridge of the M.V. Arctic was not compatible with either modern thinking on efficient bridge design or the special requirements of Arctic going vessels. In this phase of the project, all consoles on the bridge of the M.V. Arctic were replaced with new units as outlined in Canarctic's report SINSS Navigation Console Re-Design Phase I, presented to the Transportation Development Centre (Canarctic, 1988b. TP-9142).

Canarctic considered the implementation of the bridge re-design as vital, not only to allow for the proper implementation and testing of new Arctic navigation technologies, but also to aid the marketing of Canadian technology and expertise worldwide.

The philosophy that was followed for the design of the new bridge was based on a number of operational constraints.

These constraints relate to specific functions performed while operating the vessel in three transit modes (open water navigation, ice navigation and docking manoeuvres). These functions have been divided into 5 groups for which a set of design goals were defined:

1) Conning
   - Reduce navigating console size to promote access to front windows and increase moving space in front of consoles
   - Remove as many functions as possible from all front consoles to help reduce their size
   - Provide all the necessary operating information at the front consoles for the conning officer
   - Remove any visual obstacles that prevent exterior view from remote areas of the bridge (e.g. reduce chart table instrument panel height to allow an outside front view from behind the chart table).

2) Ice Navigation
   - Provide a functional and compact SINSS console that incorporates all the SINSS components
   - Provide sufficient redundancy and spare cables to permit economic and efficient implementation of future upgrades
   - Provide ice related information and enhanced marine radar imagery at the port and starboard sides of the bridge in addition to at the SINSS console
   - Provide suitable working facilities in the research area of the bridge

3) Charting
   - Increase chart table area and provide an additional chart table near the SINSS console
   - Increase chart storage area
   - Improve navigating instrument grouping around the main chart table

4) Auxiliary Functions
   - Provide adequate communications at all locations on the bridge
   - Provide controls and communications at the front consoles, for immediate action in case of emergency
   - Centralize emergency functions in one single command post
   - Rationalize emergency power distribution
   - Relocate facsimile receiver in a more remote location
   - Provide adequate pantry facilities

5) Storage, etc.
   - Provide adequate storage facilities throughout the bridge
   - Renew bridge decoration
   - Improve lighting in critical areas (chart table, main console, etc.)

2. Overall Objective

The overall objective of the work in this project was the implementation of the recommended first generation ice navigation console and the necessary bridge modifications needed to provide a platform for the continued development of SINSS in an operational environment.

2.1 Specific Objectives:

A) To build and incorporate the first generation SINSS ice navigation console onto the bridge of the M.V. Arctic.

B) To relocate/upgrade and modernize existing electronic equipment on the bridge of the M.V. Arctic to integrate operational and SINSS requirements.

C) To modify the resident instrumentation system to generate the information needed by the conning officer at the wing consoles.

D) To develop a modern bridge platform to facilitate future field evaluations of efficient ship technologies.

3. Bridge Design

In this section, a description of the redesign of the bridge of the M.V. Arctic is presented. The design of all the consoles is described, along with the redesign of the associated infrastructure. Essential information from the Phase I report has been included here to provide background on how the final design philosophy was achieved. Figures from the Phase I report have been included where necessary to illustrate where modifications to the Phase I design were implemented.

Minor revisions were made to the original design subsequent to the Phase I report of this project. A re-evaluation of the original Phase I bridge design by the navigating officers led to a redesign of the auxiliary navigating console. Additional changes of a lesser nature were proposed for the other bridge consoles, but these did not significantly impact on the original design. The changes to each element of the bridge design will be discussed in the appropriate sections.

3.1 SINSS Definition

SINSS (Shipboard Ice Navigation Support System) technology was a prime driving force for the bridge redesign. Its introduction onboard the M.V. Arctic had a significant impact on the bridge of the vessel which necessitated the bridge re-design project. SINSS incorporates a number of technologies and operating techniques that operate at three levels:

1) Strategic: Incorporates technologies and techniques that are used for long range planning and routing decisions, over several days or weeks. This information is provided by such technologies as satellite imagery (NOAA, METEOR) and SAR (Synthetic Aperture Radar).

2) Tactical: Incorporates technologies and techniques that provide information in the medium range for routing decisions within one day's sailing. This information is provided by the shipboard radar, SAR imagery, visual (binoculars) and others.

3) Close Range: Incorporates technologies and techniques that provide information in the close range to avoid immediate hazardous ice conditions that will be encountered within one hour of sailing. This information is provided by such technologies as shipboard radar, vertically polarized radar, visual, sonar (still very much a research tool) and others.

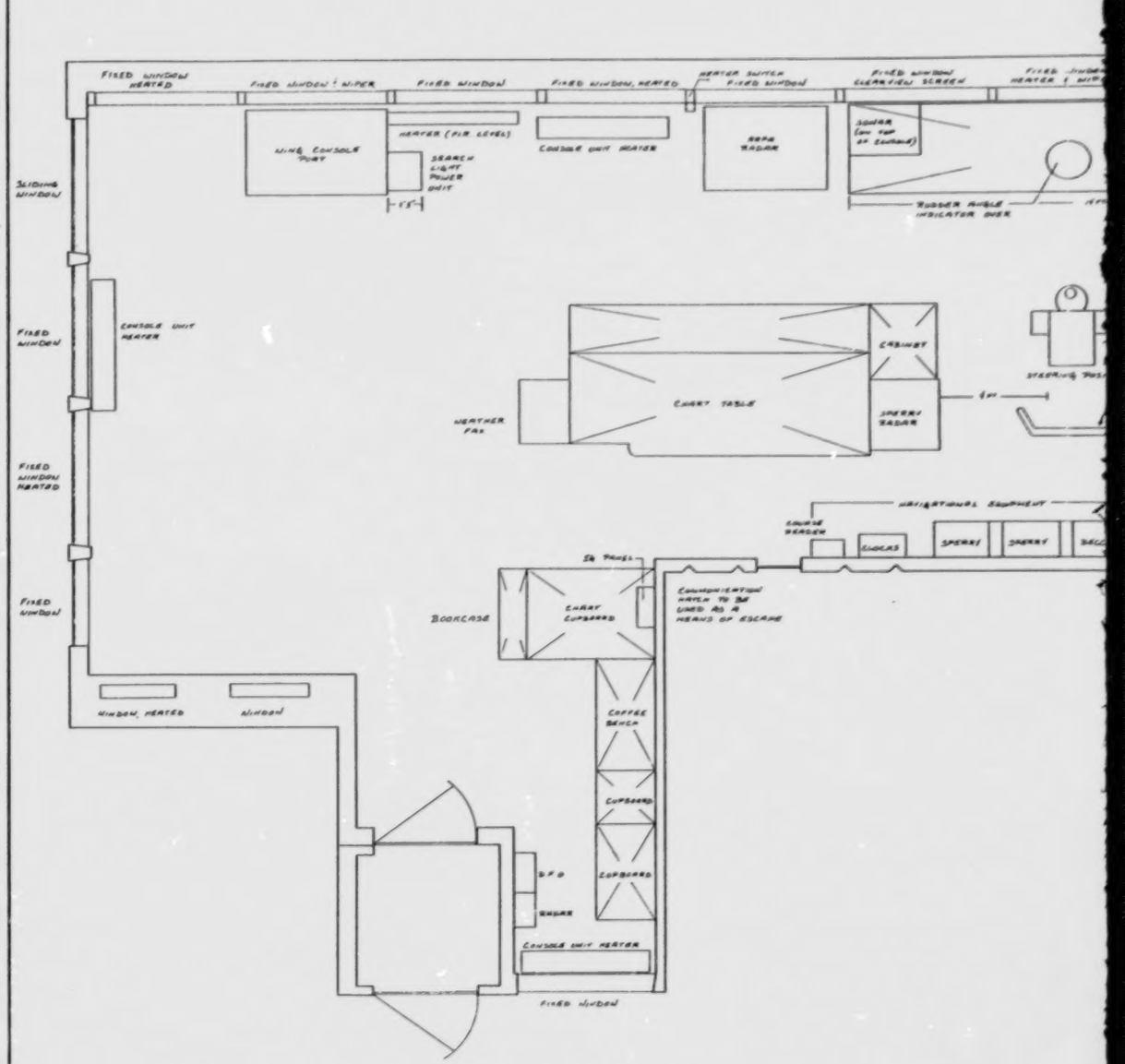
The majority of the SINSS information displays are concentrated in the SINSS console. Computers, special interfaces and displays of various sizes, convert and process the information to be used at the console. Strategic and tactical decisions are handled at the SINSS console, while close range information is generated and processed at the conning position. During difficult passages the conning officer must have at the conning position all the information and controls needed to manoeuvre the ship without having to leave his post. Two groups of information are needed at the conning position:

1) Close range information
2) Ship's operating parameters

Information relating to group #1 is supplied by the marine radars, sonar, and visual aids. Group #2 information is supplied by traditional gauges mounted on the various consoles, plus a high definition video graphics monitor mounted in each wing console. The information displayed on each can be adapted to future requirements simply by adding new software modules to the existing system. Further details on the wing console display system can be found in section 3.8 of this report.

3.2 Bridge Layout

The final design, while primarily based on the Phase I design, also considered the recommendations from the original 1985 Canarctic report entitled " Final Report on Bridge Design for Arctic Vessels (TP-7543-E). Figure 1 illustrates the bridge of the M.V. Arctic before upgrade and Figure 2 illustrates the layout of the bridge after the implementation.



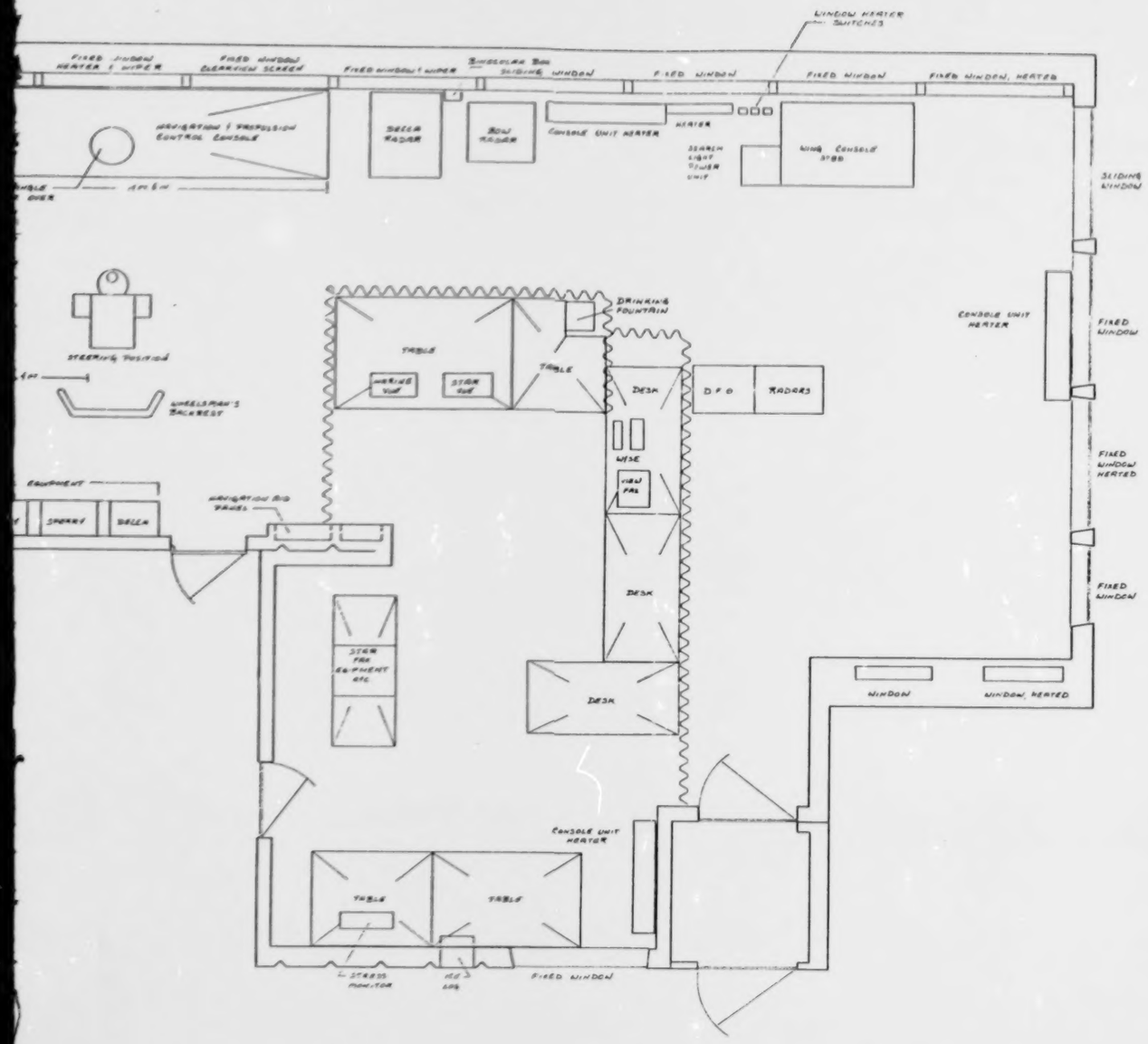


Figure 1: Main Bridge Layout Prior to Implementation

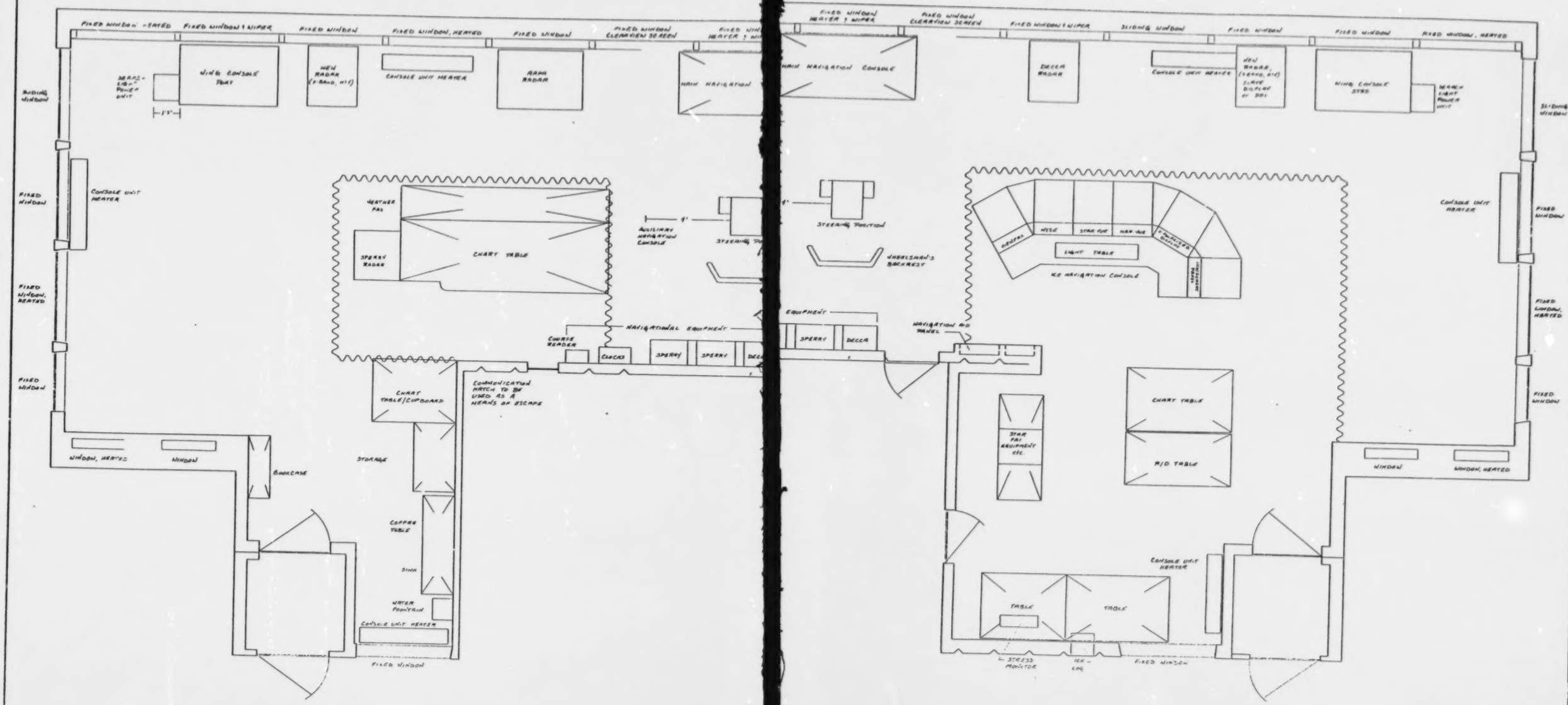


Figure 2: Main Bridge Layout After Upgrade

3.2.1 Front Console Location

The front consoles (port, centre and starboard) primarily support all functions that must be located near a conning position. Examples of this are the engine controls, depth sounder repeater, wind gauges, VHF communications, etc.

In a review of existing technologies of bridge design (Canarctic 1985), three main design philosophies were considered:

1) A bridge design where all navigation instruments are concentrated in a centralized " pilot seat " console. Such a design is best suited to small vessels with narrow beams which require high levels of manoeuvrability, such as tugs and small supply boats.

2) A bridge design where all consoles are located away from front windows and not centralized so that full access by the conning officer to the front windows is available. Such a design is suited to larger vessels which have to navigate in close quarters such as canals and buoyed channels.

3) A bridge design where consoles are installed below the front windows, against the forward bulkhead. This is the most conventional design of the three which allows the officer to operate equipment while looking forward of the vessel. However, access to the front windows is limited by the presence of the consoles.

In considering the three design philosophies noted above, design number one is not practical for a large ice breaker such as the M.V. Arctic, where the conning officer requires a clear view from both bridge wings while manoeuvring or docking in ice.

However, the principle of the first design where essential engine controls must be located at the conning position is critical as timing is extremely important during icebreaking. Therefore, the choice of a viable bridge design falls to the last two options, and ultimately one must consider the following points:

- The necessity for a clear path from one wing of the bridge to the other
- Maximum access to front windows for adequate conning
- Access to engine controls from the conning positions

The positioning of consoles away from the windows provides the benefit of direct access to all front windows. However, this design creates other problems. In order to provide the same width of access in front and behind the consoles, the chart table and all components installed in the aft section of the bridge would have to be moved back. The aft bulkhead would have to be shifted back and the radio room reduced in size. To be implemented, this design would require costly modifications to the existing bridge, that would also result in undue compromises to the radio room.

An additional disadvantage is that the conning officer would want to operate the controls from the front of the console. This implies that all directional controls would have to be operated in reverse from the normal operating position. In case of emergency, this situation could lead to confusion and cause accidents. In addition, the presence of the consoles in the middle of the bridge front creates unnecessary obstructions that have to be avoided, a situation aggravated by darkness. Extra floor space would be required to accommodate the consoles, chart table, and other facilities at the back of the wheelhouse as a consequence of their location away from the front of the bridge.

For all the above reasons, the port, centre and starboard navigation consoles were positioned at the front of the bridge, against the bulkhead in the traditional manner. Each console was reduced in width and breadth to maximize front window access.

3.2.2 Auxiliary Console Location

The auxiliary console was introduced to group all functions that are not directly required at a conning position. The introduction of the auxiliary console permitted a significant reduction in the size of the main navigation console, from which most of the components were transferred. A full description of the auxiliary console is given in section 3.3.1 of this report.

The location of the auxiliary console was addressed in Phase I of the project (Fig. 3). In Phase I, a decision was made to install the console around the steering column. A further review of the soundness of installing the console in this position led to a reconsideration based on the following arguments:

* It was decided that the Sperry S-Band display, which had been located adjacent to the starboard side of the chart table next to the steering column, be re-located to the port side. The re-location of the Sperry display was necessitated by the addition of the Arctic Marine Radar antenna on the main mast where the S-Band antenna had been located. The S-Band antenna was removed to the port side mast so the Sperry display was moved to the port side of the bridge. This re-location created space for the auxiliary console on the starboard side of the chart table.

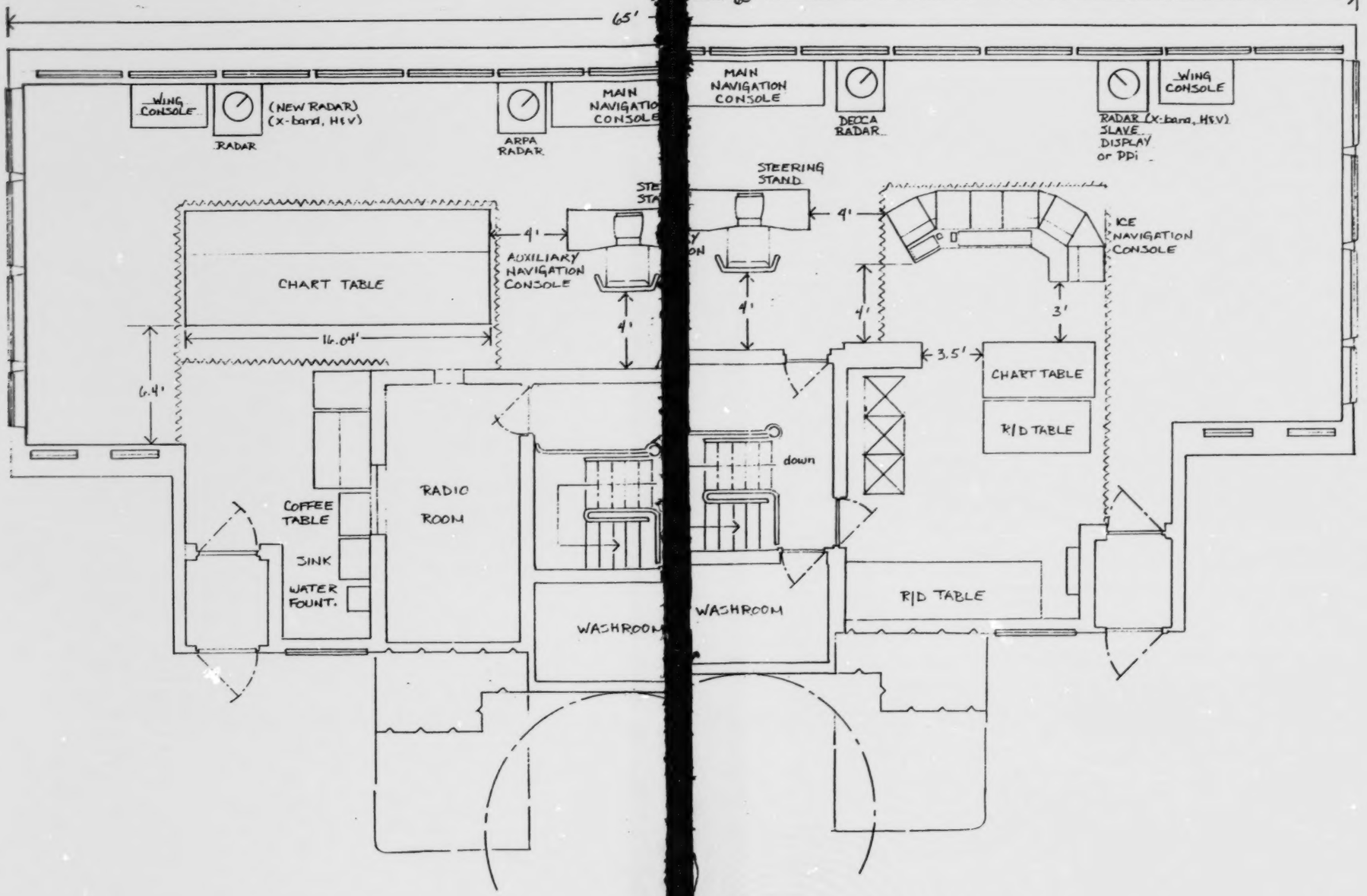
* The auxiliary console contains a full communications centre and as such is likely to be used heavily, especially in

close quarter navigation. Contrary to the first assessment, it was believed that activities associated with the auxiliary console might have a negative impact on the duties and performance of the helmsman if the console was installed around the steering column. It was feared that a high level of activity around the auxiliary console in case of emergency, might lead to incorrect manoeuvres.

* The first auxiliary console design was curved around the steering console and sloped away from the bridge front (Figs. 4A, 4B). Therefore, console instruments and facilities could only be reached from the back of the console. In the case of an emergency, the need for the conning officer to go around the end of the console to reach controls is unacceptable. The relocation of the auxiliary console to the starboard side of the chart table solved this problem by making the front of the console easier to reach from both the front and back of the bridge.

* An evaluation of the equipment to be fitted in the auxiliary console led to the conclusion that the design size of the console would be insufficient. The relocation of the console to the starboard side of the chart table would however, permit the transfer of some components of the auxiliary console to the chart table, and the size of the console would not have to be increased. The new location would also suit a more standard console shape design and therefore a better component layout on the console top and reduced fabrication costs.

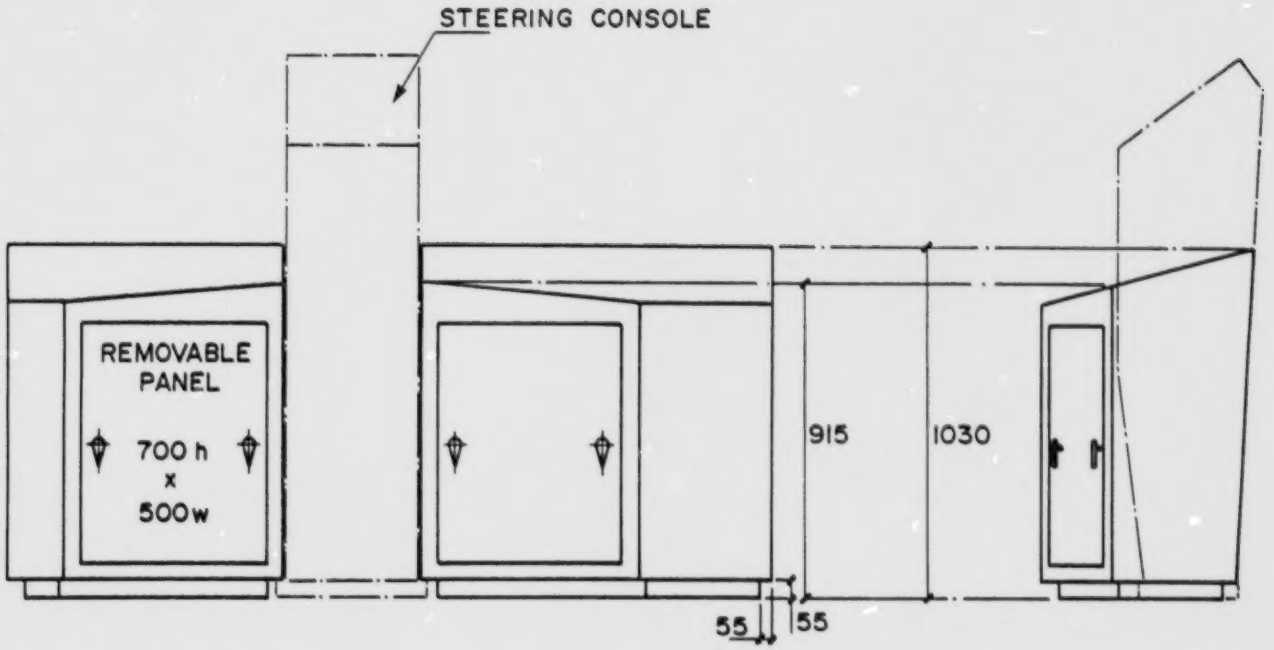
Following this evaluation, a decision was taken to relocate the auxiliary console to the starboard side of the chart table. The console was redesigned, and associated drawings modified as necessary.



PROPOSED BRIDGE LAYO

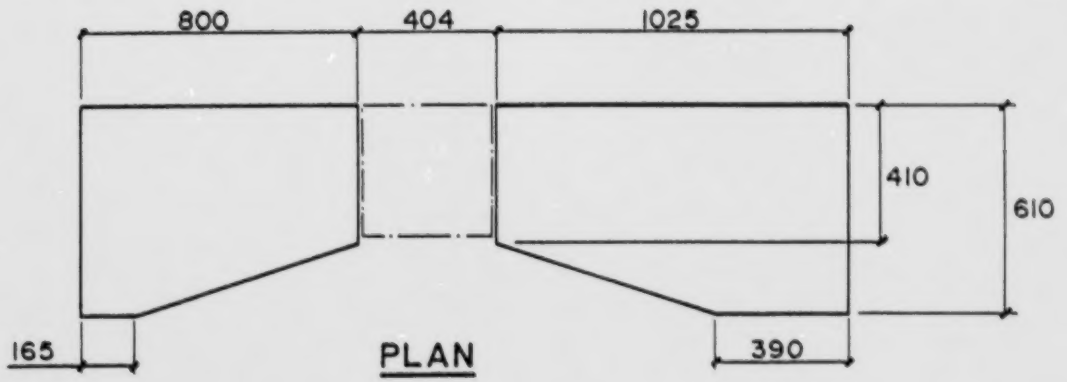
LAYOUT – MARCH 1988

Figure 3: Phase I Bridge Layout



ELEVATION

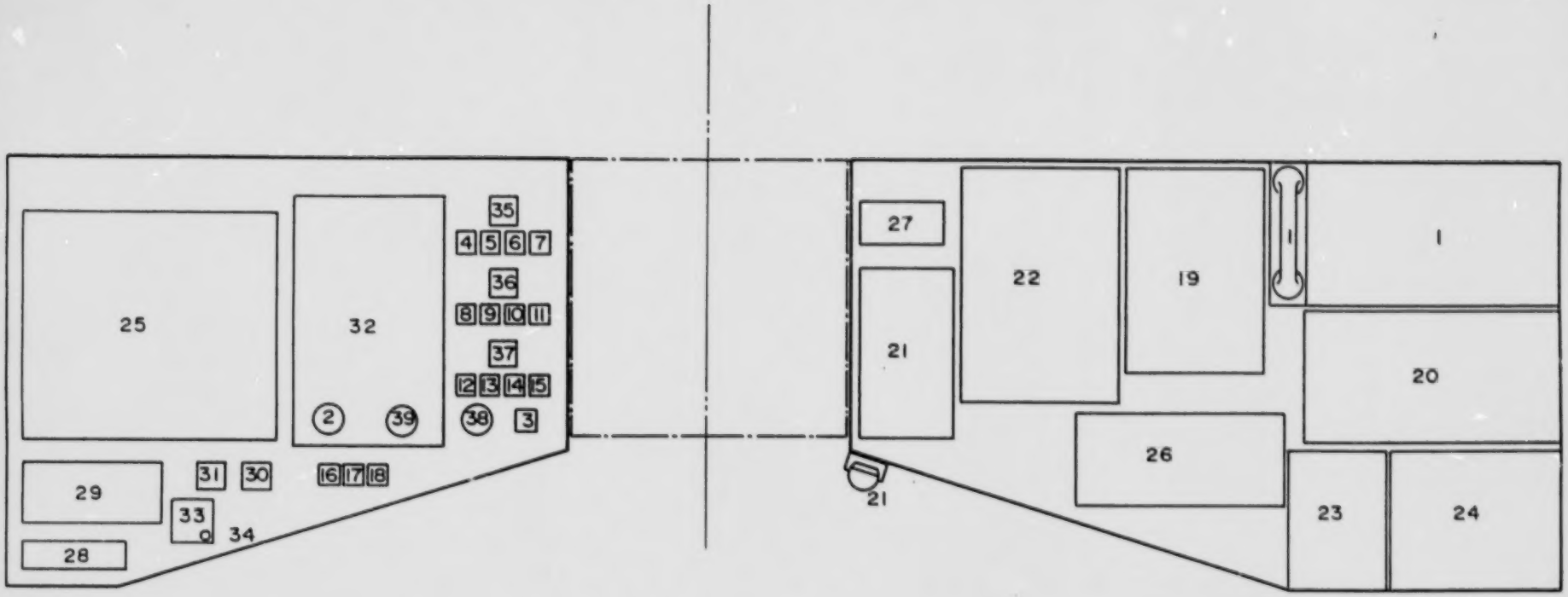
SECTION



PLAN

AUXY. NAVIGATION CONSOLE DETAIL

Figure 4A
Phase I
Auxiliary Console
Design



AUXY. NAVIGATION CONSOLE.
LAYOUT

Figure 4B
Phase I
Auxiliary Console
Component Layout

3.2.3 Radar Display Locations

Concurrent with the Bridge Upgrade project, the Arctic Marine Radar Project was undertaken also on behalf of the TDC (Canarctic 1989, in preparation). The goal of this project was to design, from available commercial components, a radar system that is specially suited to the needs of Arctic navigation. As a result of this radar project, a complete Sperry X-Band radar system, consisting of two transceivers and one RASCAR (RAster Scan Collision Avoidance Radar) display unit was purchased. The installation of the Arctic Marine Radar system was scheduled to coincide with the Bridge Upgrade project.

One of the critical aspects of the radar system layout was the physical location of the displays. Three goals guided the design of the layout:

- Reduce the distance between components of individual systems
- Provide equal information display capability on both the port and starboard sides of the bridge
- Create the least disruption to existing radar systems, in an effort to reduce the installation costs

A total of five displays were included in the design of the new bridge layout. A Decca PPI display and Decca ARPA display were retained in their original location (Fig. 1). A Raytheon PPI display, and a Sperry S-Band PPI display were retained and relocated to new positions on the bridge. The arctic marine radar display was added to the bridge to address the requirement for the simultaneous display from two different radar systems on the starboard side of the bridge.

The choice of locations for the displays was simplified by the reduced number of suitable locations on the bridge. Since the radars are actively used during ice navigation, the front area of the bridge directly in front of windows was the preferred location. These constraints reduced the available locations for the radar displays to a total of four:

- One on the port side near the wing console, and on the starboard side in the corresponding position.
- One to the port side of the main navigation console, in front of the first available window
- One to the starboard side of the main navigation console, in front of the first available window

The components associated with each radar system, such as the transceiver and associated power supply and wave guide, were relocated with the specific location and fastening arrangements to be dealt with at the time of installation. As with the radar displays, the choice of locations was limited to the available space, as indicated in Figure 5 (Arctic Marine Radar Layout).

3.2.4 SINSS Console Location

The large size of the SINSS console dictated that it could be installed only on the port or starboard side of the bridge. Since the port side of the bridge already contains the chart table, facsimile and pantry facilities, it was appropriate to locate the SINSS console on the starboard wing. In addition, since the research and development of SINSS related technology is still ongoing, the starboard location next to the research and development area is ideal.

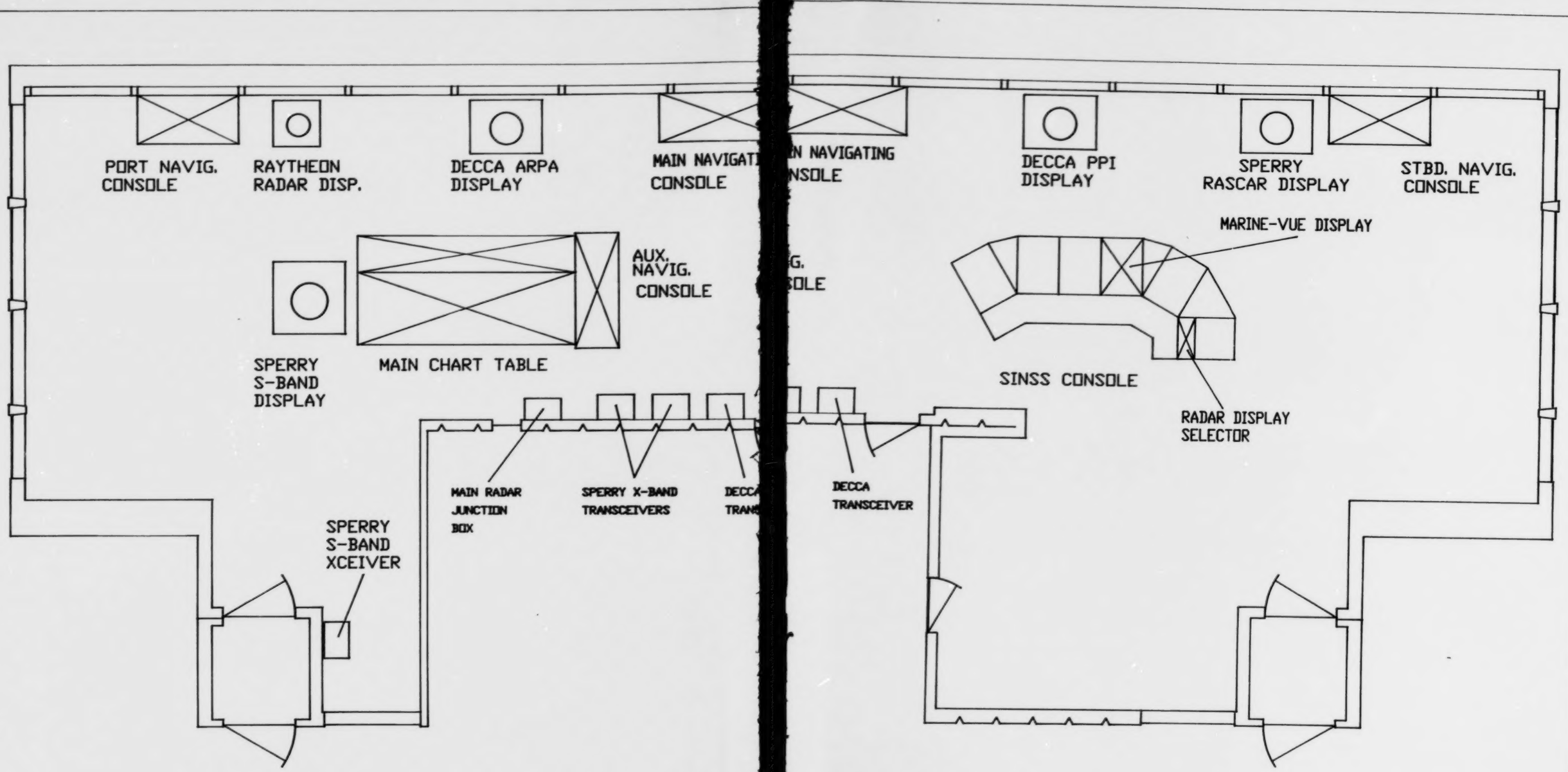


Figure 5: Arctic Marine Radar Component Layout

The console was installed facing forward leaving enough space to circulate around the console while positioning the console as close to the front of the bridge as possible. This forward position was preferred because of its proximity to the starboard conning position.

3.3 SINSS Console Design

3.3.1 Console Requirements

The SINSS console is the centre of ice navigation technology and must respond to a number of requirements. These were determined based on functional and structural considerations identified during trials with the different prototypes used from 1983 to 1988. The console requirements are as follows:

1) Must be large enough to accommodate two operators at the console
2) Must be restricted in size not to impose on the immediate bridge environment or operational requirements (viewing height, etc.)
3) Dimensions must correspond to elementary ergonomics principles
4) Must be highly modular to accommodate future modifications or expansion
5) Must be of metallic, high quality construction that allows easy access to inside components for servicing
6) Must support 19 inch rack mounted hardware technology with a total of at least 130 inches of rack space 30 inches deep
7) Must accommodate at least four 19 inch raster monitors within the central desk area
8) Must be adequately supplied with power from at least four independent power sources
9) Must be adequately ventilated to dissipate heat generated by all components mounted inside
10) Must incorporate a front desk, fitted with a dimmer controlled light table able to accommodate negative film strips of 230 mm (9 inches) wide and 1.2 m (4 feet) long.

One of the most versatile systems found, that complies with the above requirements, is manufactured by Hammond Manufacturers of Guelph Ontario (Drawings SC83289/A1 TO A8).

In addition to manufacturing standard sized modules specifically for the 19 inch format, Hammond supplies a complete selection of accessories and mounting hardware to complement their system. The alternative choice was to have the SINSS console custom built similar to the navigation consoles. It was decided to implement the SINSS console using the Hammond system, as there were no significant advantages to a custom design. In fact, a custom design would have been less flexible and would not have lent itself to modifications if required.

3.3.2 SINSS Components Description

The SINSS console comprises various components installed either inside or mounted on front module panels. The location and layout of these components is discussed in section 3.3.3, while this section describes the individual components. The rationale for grouping these particular components in the SINSS console extends beyond the function of the components alone, and includes the following:

- Grouping all SINSS related technologies in one convenient central location
- Concentration of all ice related activities in an area away from operational interference
- Maximization of electronic hardware resource usage
- Ease of change of a yet evolving technology with the least possible disruption to normal ship's operations

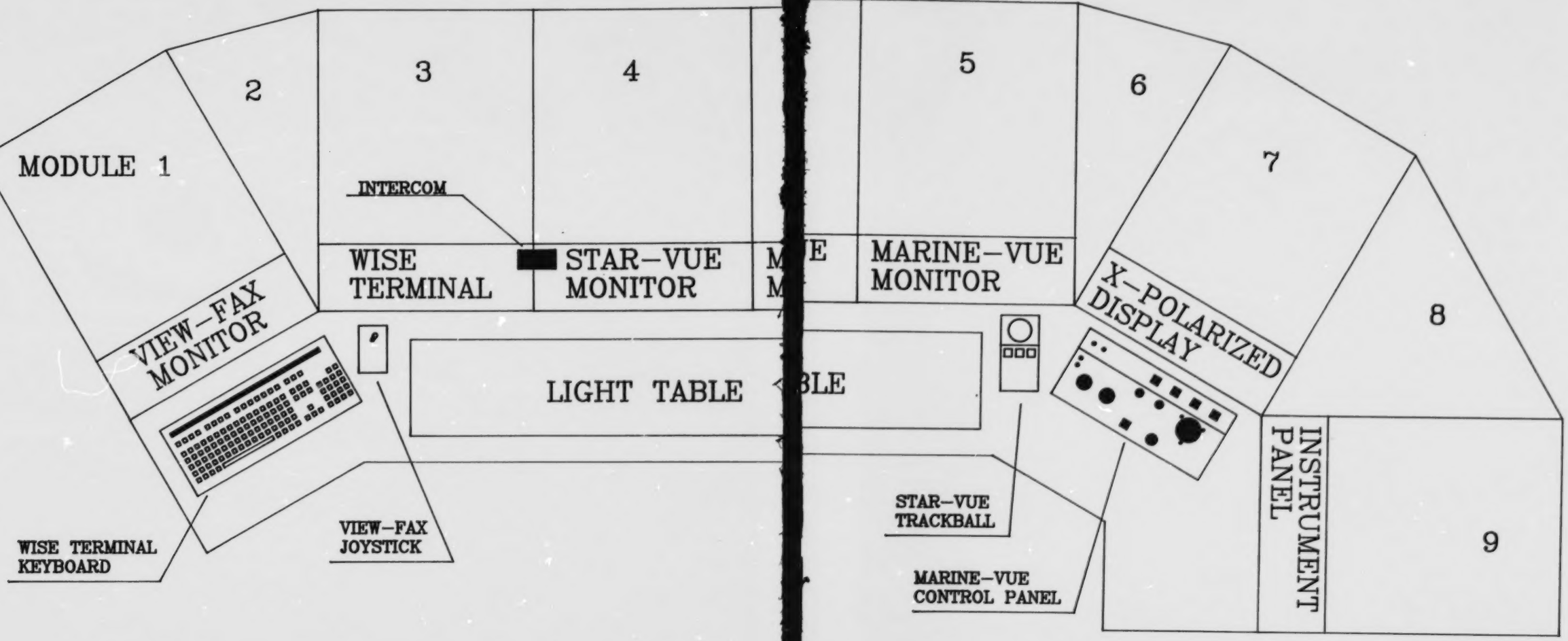
A complete list of the SINSS console components is given in table 1, while Figure 6 shows the layout of the console.

Table 1: SINSS Console Components List

MARINE-VUE		{ 2 } *
- Folsom Scan Converter	(inside module 5)	
- Video Processor Unit	(inside mod. 5)	
- MARINE-VUE Control Panel	(front desk, mod. 7)	
- Colour Monitor	(front of mod. 5)	
STAR-VUE		{1,2}
- Computer Unit	(inside mod. 4)	
- Rigid Disk Storage Unit	(inside mod. 4)	
- Expansion Unit	(inside mod. 4)	
- High Resolution Colour Monitor	(front of mod. 4)	
- Track Ball	(front desk, mod. 5)	
- Hard Copy Device	(instrument rack)	
Light Table	(front desk, mod. 3, 4, 5)	{1,2}
VIEW-FAX		{ 1 }
- Computer Unit	(inside mod. 1)	
- Rigid Disk Storage Unit	(inside mod. 1)	
- Video Processor Unit	(inside mod. 3)	
- Digital Interface Unit	(inside mod. 1)	
- Colour Monitor	(front of mod. 1)	
- Joystick	(front desk, mod. 3)	
WISE Terminal	(front of mod. 3)	{1,2}
WISE Terminal Keyboard	(front desk, mod. 1)	{1,2}
X-Polarized Display	(front of mod. 7)	{ - }
Radar Display Selector	(instrument panel, mod. 9)	{2,3}
Aviation VHF Radio	(instrument panel, mod. 9)	{1,2}
Intercom	(front of mod. 3, 4)	{2,3}
STAR-VUE UHF Downlink Receiver	(instrument panel, mod. 9)	{1,2}
Satellite Navigator	(instrument panel, mod. 9)	{ 2 }
Lehmcule Digital Gyro Repeater	(instrument panel, mod. 9)	{2,3}

* Numbers in curled brackets { } indicate the most frequent usage of the component:

1) Strategic planning
2) Tactical navigation
3) Close range navigation



SINSS ICE NAVIGATION CONSOLE (PLAN VIEW)

Figure 6 : SINSS Ice Navigation Console

MARINE-VUE:

This component of the SINSS console is used to display radar images from the various radars on board. This display is used primarily to match the radar image of local ice conditions to the SAR imagery, in order to position the vessel relative to the SAR imagery. The main component of the MARINE-VUE is the FOLSOM scan converter which converts the radial format of the radar image to a raster format for the RGB monitor. The MARINE-VUE Control Panel, in conjunction with the Video Processor Unit, allows the operator to set the range and other image characteristics, as well as perform range and bearing measurements.

STAR-VUE:

This component is used to receive, store and display SAR imagery of the ice surface, received from an aircraft. This information is used both for strategic and tactical ice navigation in combination with the MARINE-VUE component. The system consists of a computer system (two components), a mass storage unit and a high definition colour monitor. The system is controlled via a trackball located on the front desk of the SINSS console.

Light Table:

This component is used to view hard copy of SAR imagery in negative transparency format. The light table is used during tactical navigation in conjunction with the MARINE-VUE and STAR-VUE components of the SINSS console.

WISE (Reg. Tm) Terminal:

This component is a computer terminal which is used to communicate with both the VIEW-FAX and the STAR-VUE systems. It is used to "boot" or "re-boot" the STAR-VUE system, and also used, via the keyboard, to interact with the operations menu of the VIEW-FAX system. Changeover from one system to the other is handled by a switch mounted on the front of module 3 of the SINSS console.

VIEW-FAX:

This component of the SINSS console is used to receive, store, process and display satellite images of the ice surface. This information is used at the strategic level and is referred to on a regular basis during transit. This system consists of a computer system receiving information from a fax to digital interface, a mass storage unit, a video processor unit, and an RGB monitor. The system is controlled from the keyboard of the WISE terminal.

X-Polarized display:

This display has been incorporated to allow the display of alternate imagery. For example, a cross polarized radar image may be displayed on this monitor while the normal HH image is displayed on the MARINE-VUE display. Alternately, enhanced radar images may be displayed on this monitor.

Radar Display Selector:

This component is used to buffer and select radar signal sources from the vessel's radar systems. Up to four display systems can be simultaneously connected to this device. Up to four different radar signal sources can be handled by the unit. Used in conjunction with the MARINE-VUE system, it also formats the signals used by the Raytheon PPI radar display.

VHF Radio:

This component is used to coordinate SAR data transmissions from the aircraft when imagery is being collected in real time.

Intercom:

This component is used to communicate with the front navigation console, to facilitate the exchange of information between the conning officer and the officer of the watch during tactical ice navigation.

UHF Downlink Receiver:

This component receives radio signals from the SAR aircraft and outputs a data stream to the STAR-VUE system. Front controls are used to monitor the transmission in progress.

Satellite Navigator:

This component is used to monitor and update the ground referenced ship's position during tactical navigation.

Digital Gyro Repeater:

This component is used to display the ship's heading at the SINSS console, to assist in tactical navigation. The unit also transmits the heading to the MARINE-VUE system to provide a north up display of the radar images.

3.3.3 SINSS Console Layout

Three main factors determine the position of the components in the SINSS console:

- The level of utilisation
- The level of interaction with other components
- The manner in which the component is used

Certain components such as computers and related components can be installed anywhere inside the console with the only limitation of proximity to the associated display. Other components, such as display monitors, have the obvious limitation, among others, of front panel installation. Furthermore, close interaction between certain components forces their otherwise unrestricted installation in clusters of related components. Such is the case for the MARINE-VUE, STAR-VUE and light table components.

Given the relatively low component count in the console and the relative importance of certain key components, the determination of the layout was relatively straight forward. During tactical navigation, the most important components are the light table, the MARINE-VUE system and the STAR-VUE system. These components must be installed close to each other, in a position promoting ease of comparison between the different displays. The light table was installed in the centre section of the front console desk, given its length and the available desk space. The MARINE-VUE and STAR-VUE components were consequently installed in modules 4 and 5 directly behind the light table. The STAR-VUE display was installed in module 4, closer to the WISE terminal which is located in module 3.

The VIEW-FAX system is the most frequently used component of the SINSS console, and is used most of the year by the navigating personnel for strategic planning or for weather monitoring purposes. The monitor was installed in module 1, near the WISE terminal which is used to control it. This position is also closer to the main navigation area of the bridge and therefore more accessible to the navigating personnel.

Positioning of the remaining components was less critical, and was largely determined by installation and maintenance convenience. Small components were grouped in the front panel of module 9 in a convenient arrangement called the instrument panel.

Most other components of the console are internally mounted. Adequate cable fastening facilities and power distribution were provided inside the console, making installation and maintenance of components very easy. All front and back doors, as well as panelling are removable. Adequate ventilation was provided inside the console to dissipate the heat generated by the electronic equipment.

The front console desk is mounted at a height of 89 cm. This height allows the operator to work on the light table while standing up, yet is low enough to permit a comfortable sitting position. The total console width is such that any front mounted instrument can easily be reached while standing in front of the console.

3.4 Navigating Console Design

3.4.1 Functional Distribution of Bridge Components

The size of the front consoles is directly related to the number of components they must accommodate. Consequently, a minimum console size will be achieved by transferring as many functions as possible to the auxiliary console or other suitable locations. The distribution of components among the bridge consoles was made at a group level (e.g. steering gear controls, or engine room warning indicators). The functional groups are listed below:

Engine controls: These consist of the combinator and the associated station selection switches and indicators

Engine/bridge transfer controls/alarm cluster: These controls are the engine room/bridge changeover controls and engine alarm/status indicators

Emergency controls: These include the general alarm, whistle controls, fire door release, sound powered telephone, telegraph, etc.

Radio communications: All HF, VHF, and satellite communications

Internal comm.:	Shipboard switched telephone exchange and emergency telephone
Navigation aids:	Loran, Decca, Direction Finder, Sat-Nav etc..
Auxiliaries:	These include search light controls, window wipers and window heaters etc.
Bubbler/bow thruster:	These controls are related to the bubbler system when remotely controlled from the bridge

Changes in the distribution of components were focused on the main navigating console and the auxiliary console. Few changes were made in other areas of the bridge and will not be discussed here. Some controls such as the window wipers and window heater controls were mounted directly on the forward bulkhead, providing further reductions in the size of the front consoles.

Tables 2, 3 and 4 list the console components before and after the upgrade, while Figures 7 through 9 show the layout of all the navigation consoles after the upgrade.

3.4.2 Front Console Profile

The design of the console profile (Figure 10), was influenced by the following requirements:

1) Maintain an unobstructed view out of the front windows
2) Reduced console obtrusiveness
3) Slanted instrument panel
4) Quasi-horizontal control panel
5) Positioned against bulkhead
6) Available height below window frame

Table 2 : Wing Console Component Lists

New Wing Console List of Components

1 Steering control
2 Whistle control
3 Pitch indicator
4 Shaft RPM indicator
5 Combinator
6 Morse key
7 Port bubbler on (lighted pushbutton)
8 Port bubbler off (pushbutton)
9 Stbd bubbler on (lighted pushbutton)
10 Stbd bubbler off (pushbutton)
11 Bow thruster on (lighted pushbutton)
12 Bow thruster off (push button)
13 Bow thruster port (indicator light)
14 Bow thruster stbd (indicator light)
15 Bow thruster selector switch
16 Control point indicator light
17 Console select switch port/stbd (lighted pushbutton)
18 Port compressor on (indicator light)
19 Stbd compressor on (indicator light)
20 Dimmer control
21 Scale light switch/dimmer
22 -
23 W/H on service (indicator light)
24 Port/Stbd station on service (push button lighted switch)
25 Pitch is reduced (indicator light)
26 Ship performance monitor (new item)
27 HF radio remote handset (side of console) (new item)
28 Rudder angle indicator (new item)
29 Engine RPM indicator (new item)
30 Sound powered telephone (new item)
31 Sailor VHF units (new item)
32 Ship's telephone (new item)
33 Clutch release (push button) (new item)
34 Intercom to SINSS console (new item)
35 Search light aiming control
36 Search light on/off switch
37 Search light beam width

- Items 3, 4, 28, 29, are arranged in a standard configuration repeated on all navigation consoles.

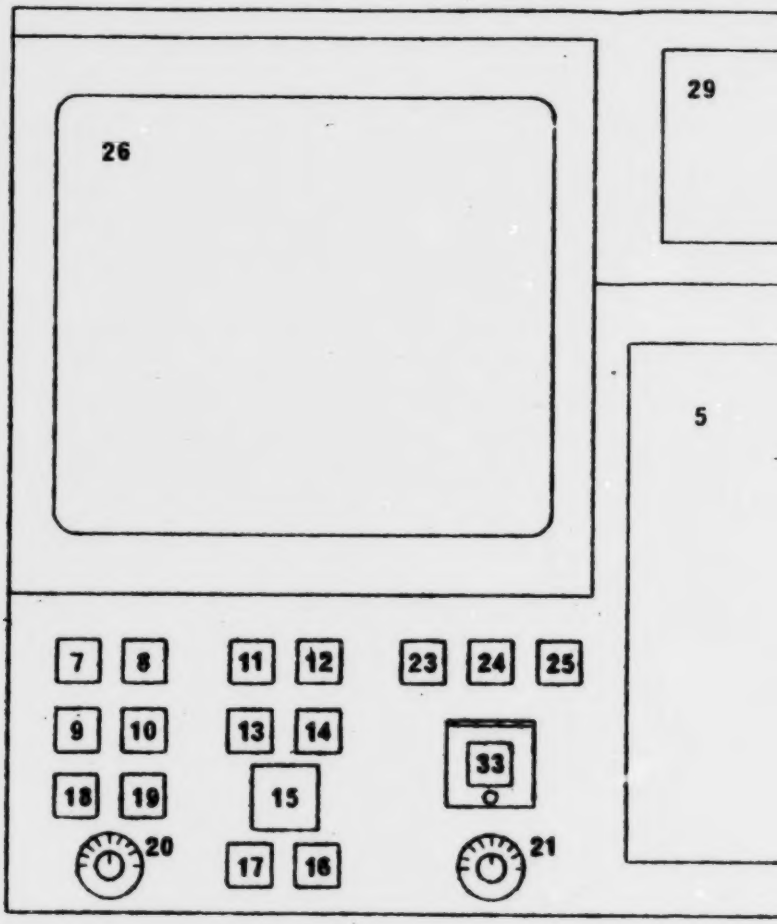
- All switches are new and of uniform design.

- All indicator lights have been replaced with uniform design. Labels are printed direcly on glass to save space.

- Manufacturers panels have been removed and switches and indicator lights are mounted directly on the console top.

Old Wing Console List of Components

1 Steering control
2 Whistle control
3 Pitch indicator
4 Shaft RPM indicator
5 Combinator
6 Morse key
7 Port bubbler on (lighted pushbutton)
8 Port bubbler off (pushbutton)
9 Stbd bubbler on (lighted pushbutton)
10 Stbd bubbler off (pushbutton)
11 Bow thruster on (lighted pushbutton)
12 Bow thruster off (push button)
13 Bow thruster port (indicator light)
14 Bow thruster stbd (indicator light)
15 Bow thruster selector switch
16 Control point indicator light
17 Console select switch port/stbd (lighted pushbutton)
18 Port compressor on (indicator light)
19 Stbd compressor on (indicator light)
20 Dimmer control
21 Scale light switch/dimmer
22 Whiper controls (moved to bulkhead)
23 W/H on service (indicator light)
24 Port/Stbd station on service (push button lighted switch)
25 Pitch is reduced (indicator light)
26 -
27 -
28 -
29 -
30 -
31 -
32 Ship's telephone (handset only, no dial or answer capability)
33 -
34 -
35 Search light aiming control
36 Search light on/off switch
37 Search light beam width control



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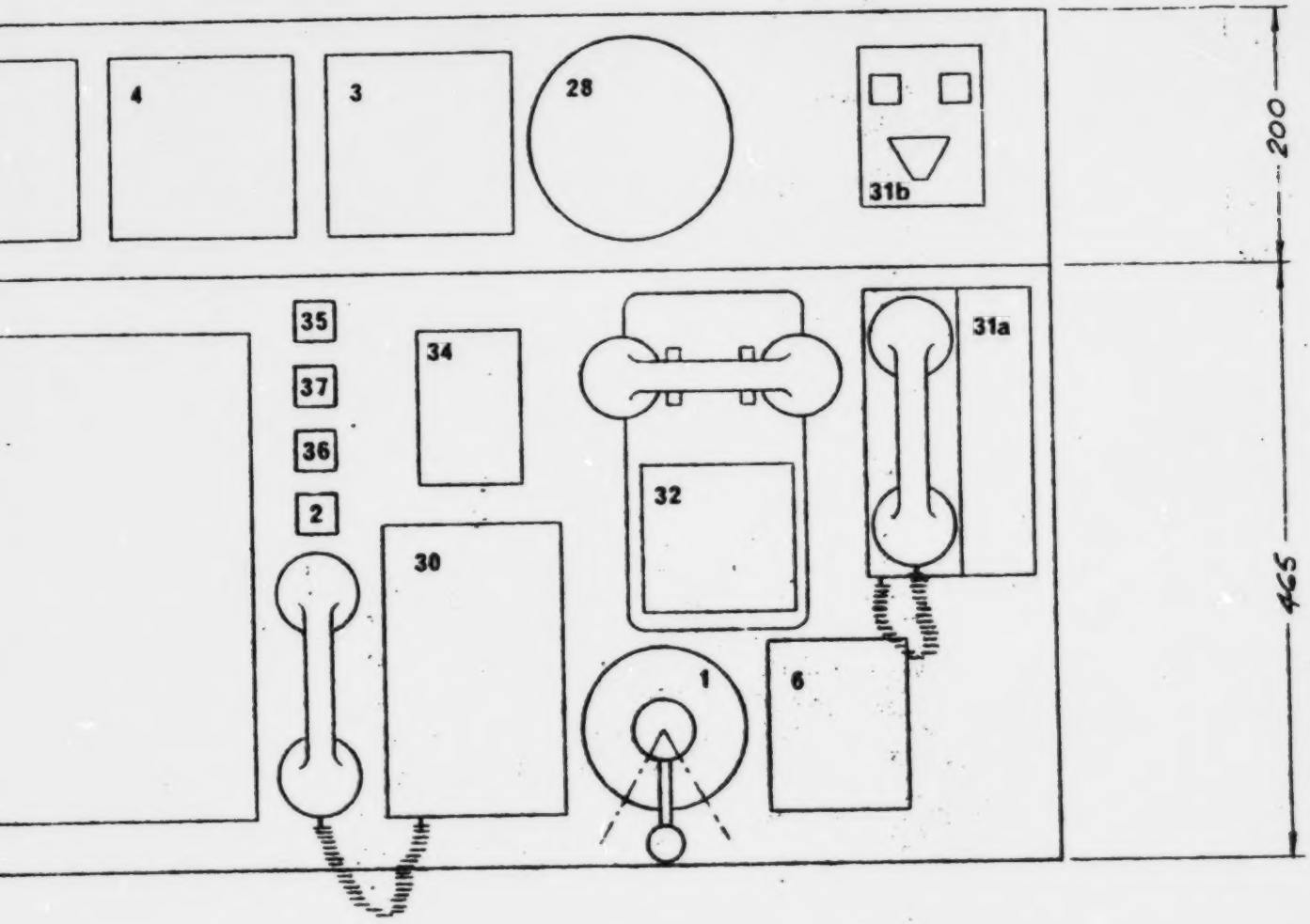


QUIPMENT LAYOUT

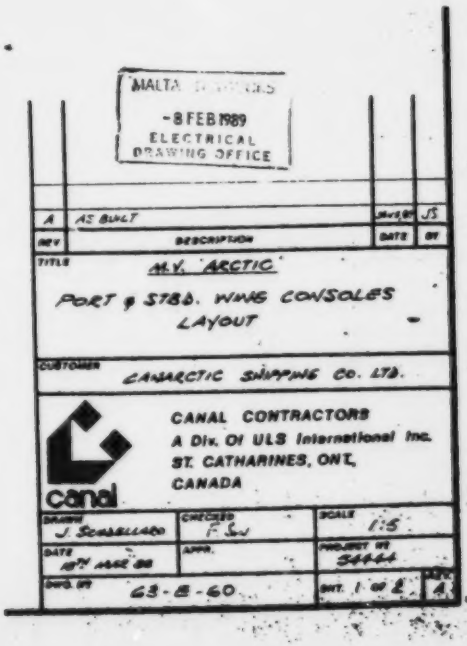


Figure 7: Wing Console Layout

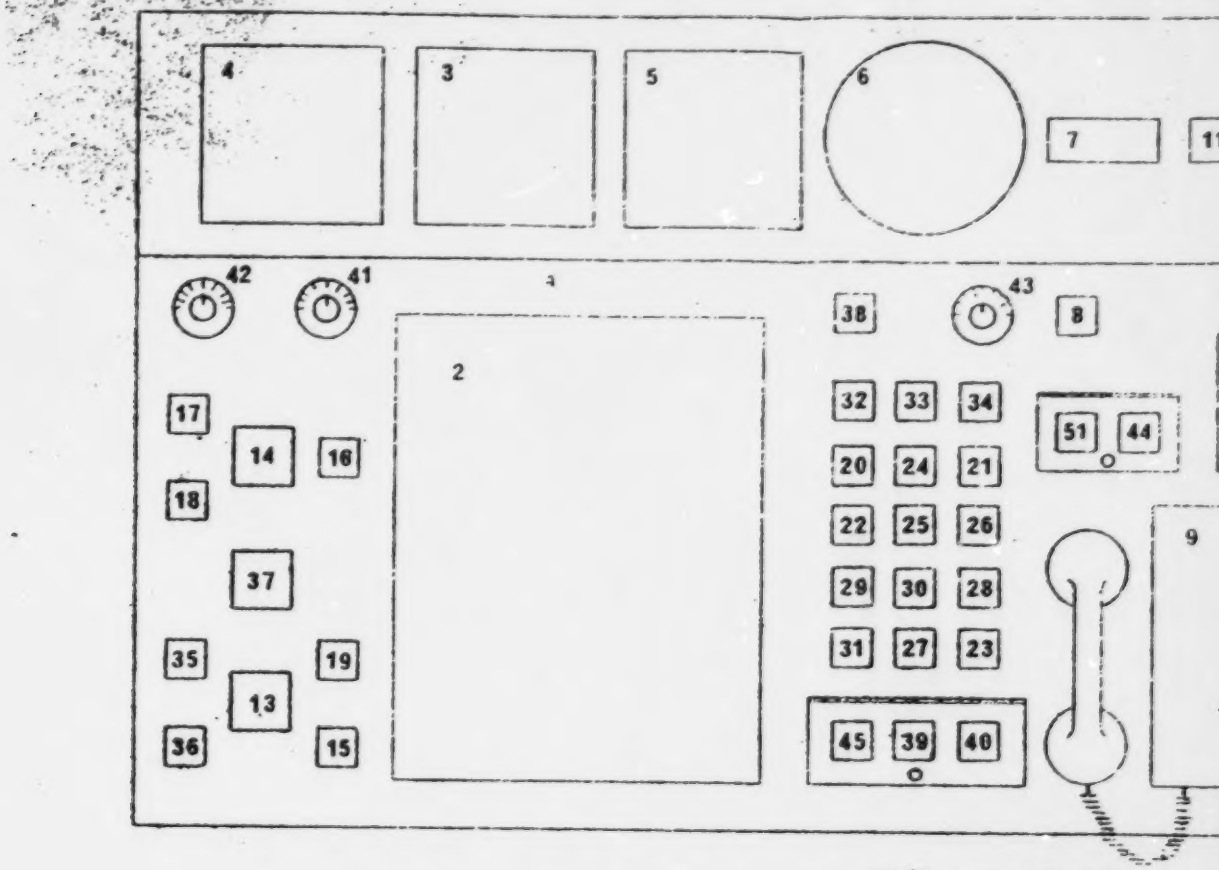
Table 3: Main Console Component Lists

New Main Console List of Components

1	Ship's telephone (D/L to E/R, P/A and dial)	(new unit)
2	Combinator	(recouped unit)
3	Engine RPM indicator gauge	(new gauge)
4	Shaft RPM indicator gauge	(new gauge)
5	Pitch indicator gauge	(new gauge)
6	Rudder angle indicator gauge	(recouped unit)
7	Digital gyro repeater	(new display)
8	Whistle control (push button only)	
9	Sound powered telephone	
10a	VHF control unit for Sailor RT146	(new unit)
10b	VHF radio remote control box. Sailor model M410	
11	Speed log repeater digital display	(new display)
12	HF radio remote handset	(new unit)
13	Combinator mode control	
14	Engine room/bridge changeover control	
15	Pitch is reduced indicator light	
16	Ready for takeover indicator light	
17	Wheelhouse on service indicator light	
18	Engine room on service indicator light	
19	Load protection off indicator light	
20	Engine auto stopped indicator light	
21	Emergency stop from E.C.R. indicator light	
22	Engine auto declutched indicator light	
23	Safety system overriden from E.C.R. indicator light	
24	Stop engine indicator light	
25	Declutch engine indicator light	
26	Clutch engagement blocked indicator light	
27	Overload indicator light	
28	Safety system on indicator light	
29	Clutch engaged indicator light	
30	Clutch disengaged indicator light	
31	Wrong pitch alarm	
32	Spare indicator light	
33	Spare indicator light	
34	Spare indicator light	
35	Ahead pitch illuminated push button	
36	Astern pitch illuminated push button	
37	Center console control position illuminated push button	
38	Lamp test push button	
39	Emergency stop lighted maintained push button	
40	Safety override lighted maintained push button	
41	Dimmer, scale lights and combinator	
42	Dimmer, pitch control indicator lights	
43	Dimmer, engine alarms	
44	Fire door release, accomodation fan shut down push button	
45	Clutch release push button	(new item)
46	Wind direction indicator gauge	(new item)
47	Wind speed indicator gauge	(new item)
47a	Dimmer for 46 and 47	
48	Depth sounder repeater	(moved from chart table)
49	Clock	(new item)
50	Intercom to SINSS console	(new item)
51	General alarm, maintained push button	
52	Ice log digital display	(new item)
53	Dimmer for 7, 11 and 52	

Old Main Console List of Components

1	Ship's telephone	(control head, moved to auxiliary console)
2	Combinator	
3	Engine RPM indicator gauge	
4	Shaft RPM indicator gauge	
5	Pitch indicator gauge	
6	Rudder angle indicator gauge	
7	Gyro repeater	(analog type mounted on top of console)
8	Whistle control/horn	(control head moved to aux. console)
9	Sound powered telephone	
10a	VHF radio #1	(moved to aux console)
10b	VHF radio #2	(obsolete equipment)
11	Speed log	(main control unit, moved to chart table)
12	-	
13	Combinator mode control	
14	Engine room/bridge changeover control	
15	Pitch is reduced indicator light	
16	Ready for takeover indicator light	
17	Wheelhouse on service indicator light	
18	Engine room on service indicator light	
19	Load protection off indicator light	
20	Engine auto stopped indicator light	
21	Emergency stop from E.C.R. indicator light	
22	Engine auto declutched indicator light	
23	Safety system overriden from E.C.R. indicator light	
24	Stop engine indicator light	
25	Declutch engine indicator light	
26	Clutch engagement blocked indicator light	
27	Overload indicator light	
28	Safety system on indicator light	
29	Clutch engaged indicator light	
30	Clutch disengaged indicator light	
31	Wrong pitch alarm	
32	-	
33	-	
34	-	
35	Ahead pitch illuminated push button	
36	Astern pitch illuminated push button	
37	Center console control position illuminated push button	
38	Lamp test push button	
39	Emergency stop lighted maintained push button	
40	Safety override lighted maintained push button	
41	Dimmer, scale lights and combinator	
42	Dimmer, pitch control indicator lights	
43	Dimmer, engine alarms	
44	Fire door release	
45	-	
46	-	
47	-	
47a	-	
48	-	
49	-	
50	-	
51	General alarm, maintained push button	
52	-	
53	-	
54	Telegraph	(moved to aux. console)
55	Steering motor controls	(moved to aux. console)
56	Window heaters (2)	(moved to bulkhead)
57	Wiper controls (3)	(moved to bulkhead)
58	FWD search light controls (3)	(moved to aux. console)
59	Inmarsat terminal.	(moved to aux. console)



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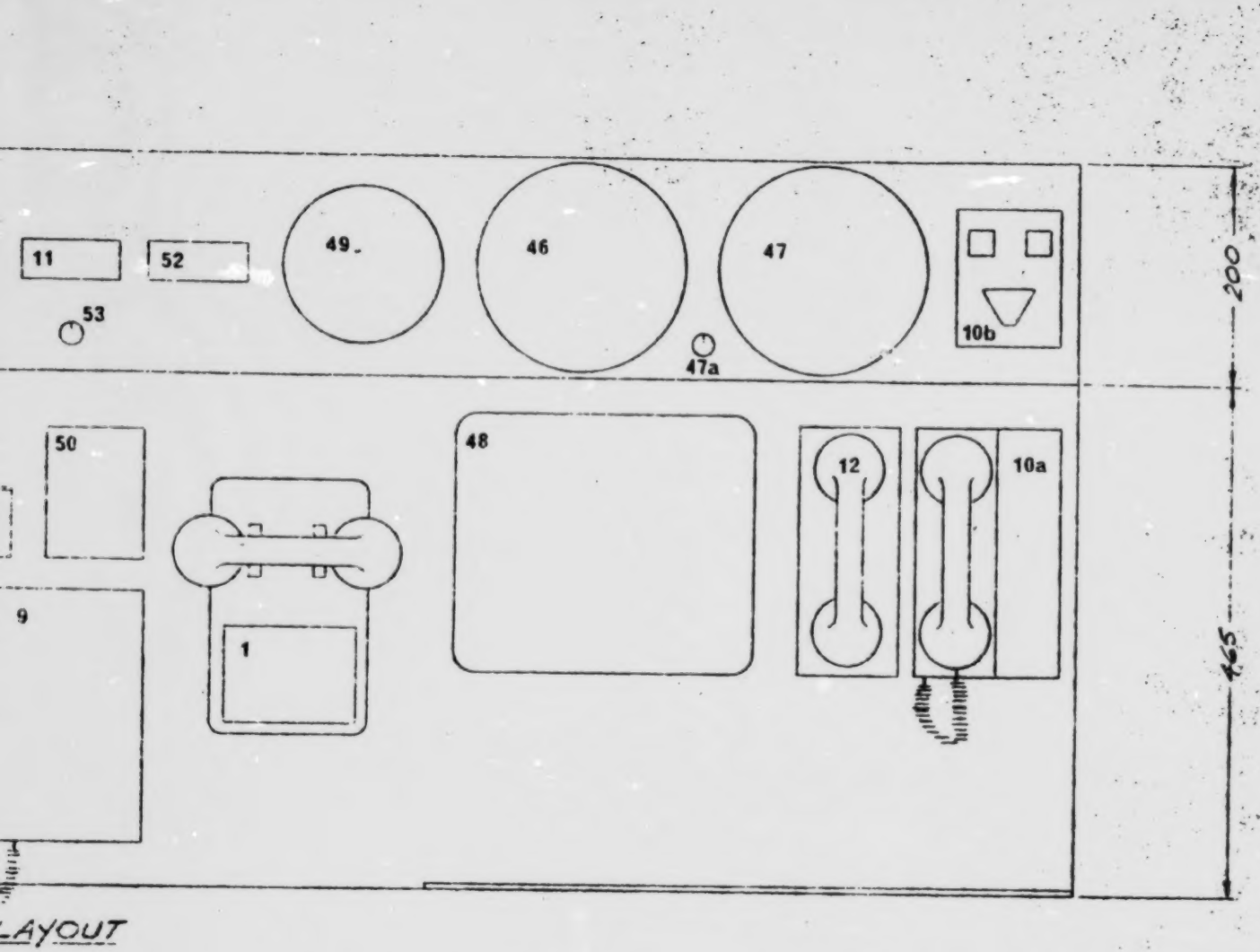


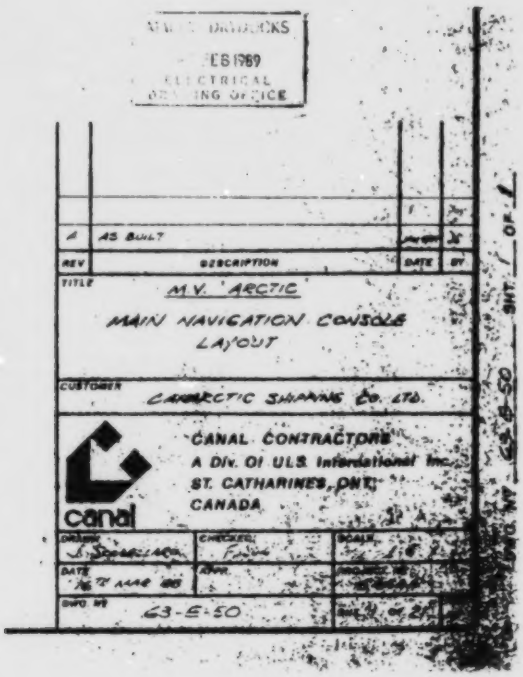
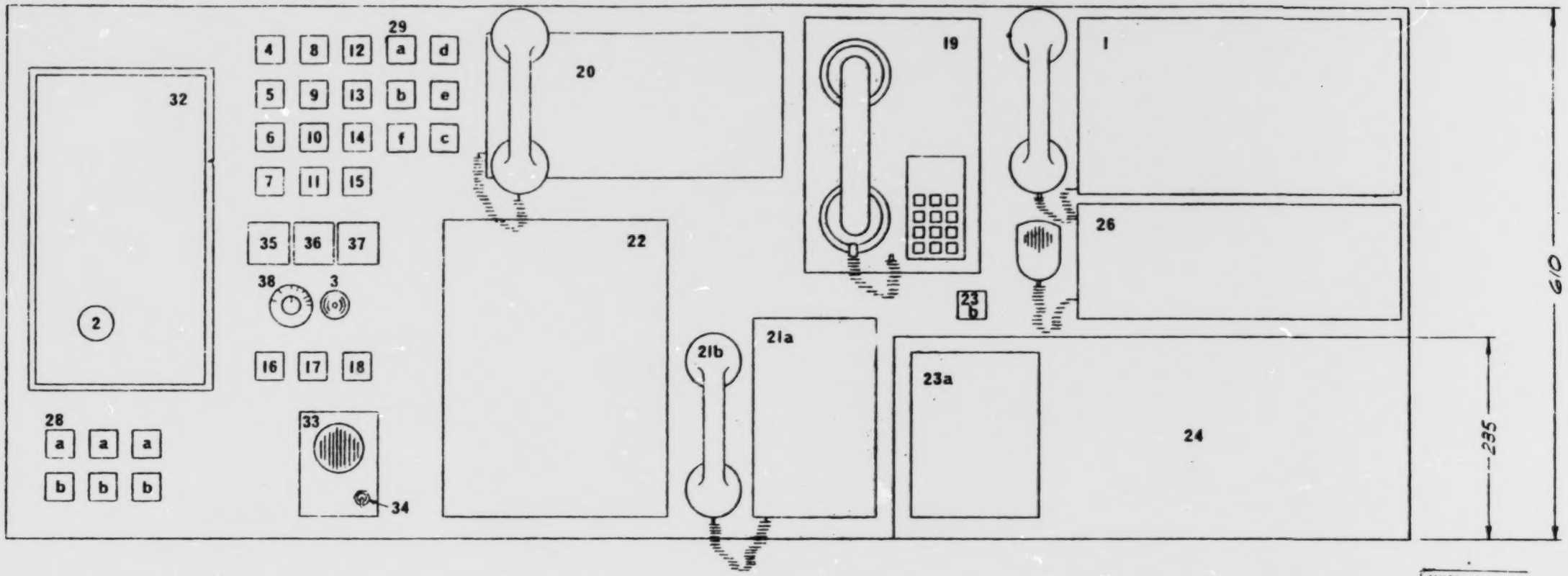


Figure 8: Main Console Layout

Table 4: Auxiliary Console Components List

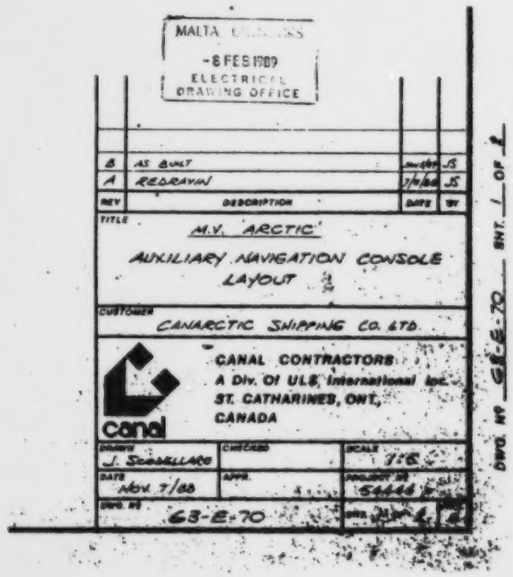
1	HF radio (Debeg)
2	Telegraph wrong way alarm
3	Steering gear alarm sounder
4	No. 1 steering motor run indicator light
5	No. 1 steering motor ready on std-by indicator light
6	No. 1 steering motor normal power available indicator light
7	No. 1 steering motor emergency power available ind. light
8	No. 2 steering motor run indicator light
9	No. 2 steering motor ready on std-by indicator light
10	No. 2 steering motor normal power available indicator light
11	No. 2 steering motor emergency power available ind. light
12	No. 3 steering motor run indicator light
13	No. 3 steering motor ready on std-by indicator light
14	No. 3 steering motor normal power available indicator light
15	No. 3 steering motor emergency power available ind. light
16	Spare indicator light
17	Spare indicator light
18	Spare indicator light
19	Inmarsat terminal
20	VHF radio
21a	Sound powered telephone
21b	Sound powered telephone handset
22	Ship's telephone control head
23a	Tape recorder
23b	Tape recorder source select switch
24	Writing space
25	-
26	HF radio (Harris) (moved from chart table)
27	-
28a	Fwd searchlight on/off/start switch
28b	Fwd searchlight overtemp. indicator light with test
29a	Whistle code selector switch
29b	Whistle selector switch
29c	Fwd whistle heater switch/indicator light
29d	Whistle code start pushbutton/indicator light
29e	Whistle "at will" pushbutton
29f	Aft whistle heater switch/indicator light
30	-
31	-
32	Telegraph
33	SINSS console intercom extension speaker
34	Cut off switch for SINSS extension speaker
35	No. 1 steering motor selector switch
36	No. 2 steering motor selector switch
37	No. 3 steering motor selector switch
38	Dimmer for steering motor indicator lights

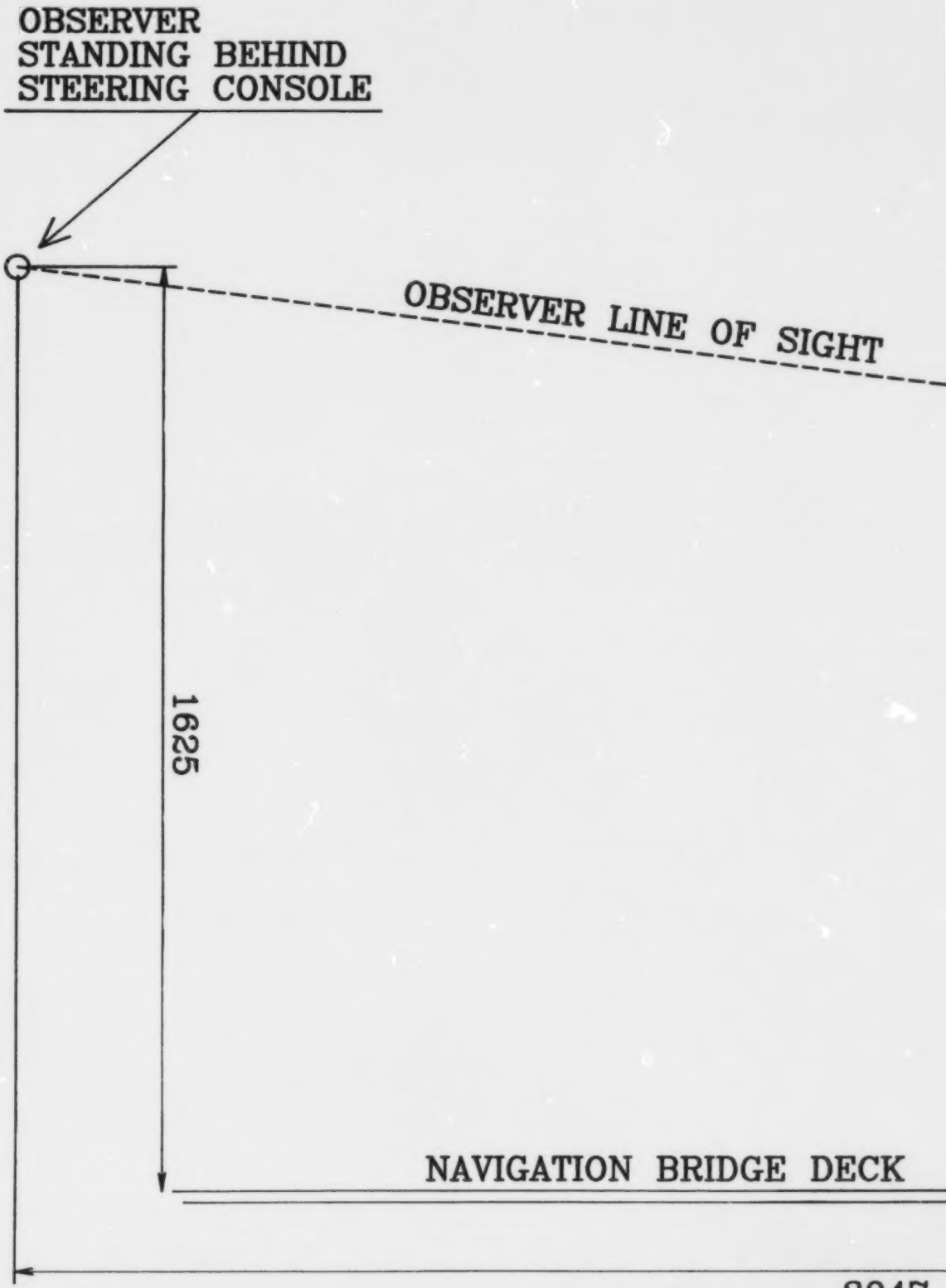
* All items moved from main navigation console, unless otherwise indicated.



EQUIPMENT LAYOUT (SHOWN FLAT)

Figure 9: Auxiliary Console Layout




OBSERVER
STANDING BEHIND
STEERING CONSOLE
OBSERVER LINE OF SIGHT
1625
NAVIGATION BRIDGE DECK
3047

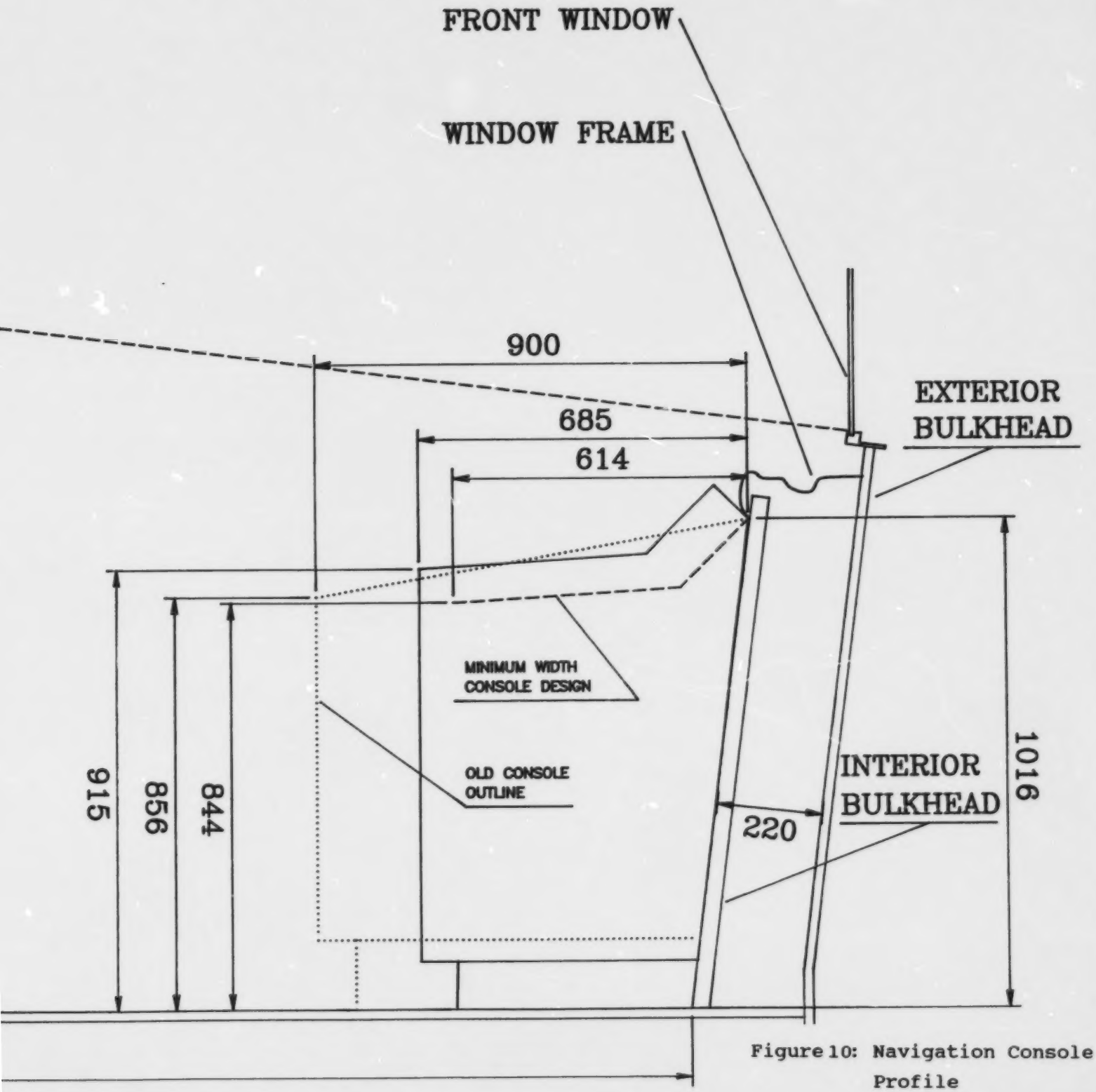


Figure 10: Navigation Console Profile

Requirements 3 and 4 point to a dual surface console top. The instrument panel was designed to be slanted at a favourable viewing angle (near 45 deg.), while the control panel was to be quasi-horizontal (only a slight backward slant of 10 deg.). The instrument panel must accommodate instruments of a maximum size of 200 mm. and therefore must be at least this width. The width of the control panel was set at 465 mm to accommodate the combinator which is the largest component to be fitted. The maximum height available below the front window is 1016 mm. This height must correspond to the height of the back of the console if the console is to butt against the forward bulkhead without overlapping the window frame.

A minimum width console design is obtained when the top of the instrument panel butts against the front bridge bulkhead. Given the above measurements, this would result in a console top standing at 844 mm above deck level at the front of the console. A minimum of 900 mm was considered necessary for the console top and therefore the 844 mm figure was unacceptable. In addition to the height requirement, the instrument panel components require a minimum depth of 100 mm inside the console. These two requirements increased the console width by 71 mm, while the top height at the front of the console was brought to 915 mm. The maximum height of the console has also been considered. A wheelsman standing behind the steering column should have a clear view of the window in front of him. An unobstructed view of the ship's bow is essential to the wheelsman. Therefore, the bottom of the window must be unobstructed to a man standing behind the steering column. A line of sight was drawn from the estimated observer position to the bottom of the window. The top of the console is clearly not in the way and would not be for any operator regardless of height.

In order to reduce cost, the same profile was used for all front consoles. The main console was made longer than the wing consoles to accommodate the additional instruments and controls.

3.4.3 Component Selection

The choice of new components to fit in the upgraded consoles was a significant factor in the final size of the consoles. The large components, such as the combinator, the telegraph and the video monitors were key determinants in setting the depth of the consoles. However, the other dimensions were determined by the size of the smaller components such as the indicator lights and switches, to be fitted in the consoles. The criteria used in the selection of these components are listed below:

- Size of switches and indicators
- Geometry of devices
- Style of switches and indicators
- Labelling method

One reason for the large size of the old consoles, is the incorporation of manufacturer supplied control panels on the console top. This was avoided in the new design, by replacing all supplied panels by console top mounted switches and indicators of uniform design. The uniform design allows a more compact and orderly disposition of components on top of the console.

A significant amount of console top space was saved by choosing indicator lights and switches for which the labelling is made directly on the lens instead of below the indicator lights on a separate label. The size of the indicator lights was chosen to facilitate reading the label from a distance of at least four feet.

Other components such as pitch or RPM indicators were supplied by specialised suppliers, and a very restricted choice of styles and sizes was available. The components were selected to promote uniformity and compatibility with recouped indicators from the old consoles.

3.5 Chart Table Modifications

In order to reduce the obtrusiveness of the chart table instrument panel it was necessary to modify the chart table top, lowering it to a more acceptable level. To allow the reduction in height, the instrument layout in the panel was redesigned. In addition to the height reduction requirement, a request was made by the navigating personnel to increase the chart table area. Over the years, installation of supplemental instruments to the original design encroached on the chart table surface, significantly reducing it.

The new design was made on location following discussions with the master and navigating personnel. Four objectives guided the design of the instrument panel:

- Reduce the height of the console top
- Concentrate related and heavily used instruments in the centre location
- Restore as much chart table area as possible
- Improve access to panel mounted instruments

To improve access to the instrument panel it was necessary to bring it forward, closer to the operator. The bottom of the instrument panel was raised 10 cm above the chart table and it was brought forward 8 cm, so that the full chart table width was still available under the panel. Obsolete instruments were removed and the remaining instruments were grouped in order of importance.

The echo sounders were installed at the right hand side of the instrument panel in a recessed position relative to the instrument panel front. The wind indicators were mounted on the face of the cable trunk that extends from the deckhead to the chart table top.

With the new layout, the chart table top was reduced by a full 19 cm, which was sufficient to restore a full view of the front of the wheelhouse.

3.6 Auxiliary Areas

3.6.1 Pantry Area

Any work requiring personnel to remain on location for any length of time necessitates the area to be equipped with suitable pantry facilities. Adequate equipment to prepare hot beverages and maintain a clean, sanitary environment must be provided. The old bridge design did not incorporate such facilities and this was often reported to be a significant annoyance. The following were included:

-Storage cabinets
-Sink with hot and cold water
-Drinking water fountain
-Sufficient counter space

In addition to these items, one large book cabinet and a book shelf were added. In the same area, the chart storage cabinet was modified, the top of which was transformed into a small chart table. The weather facsimile recorder was moved from the port side of the main chart table, and mounted at the end of the chart storage cabinet. This was made necessary by the installation of the S-Band display to the port side of the main chart table. It turns out that this location has better lighting conditions and the night time operation of this device will be easier.

3.6.2 Research Area

The new SINSS console; by its size, appearance and position, created new requirements for the other components of the research area of the bridge. A new chart table was required close to the SINSS console, to be used during tactical navigation. The presence of the console and the chart table in the research area restricted the available space for ancillary components such as working desks or storage cabinets. The following components were added in the new research area layout:

- Working desk
- Equipment racks for special projects
- Chart table

These items were incorporated in the layout, and designed to occupy the available space in the research area. The chart table was positioned as close as possible to the SINSS console, to facilitate interactions between navigators and SINSS operators. The desk was installed at the back of the chart table, leaving ample circulating room around it and in front of the adjacent entrance. The equipment racks were retained in their former positions.

3.7 Electrical

One of the goals of this project was to ensure that all electrical systems would meet the requirements of the modifications, as well as provide sufficient redundancy to facilitate future modifications or installations. In order to reduce implementation costs, the new navigation consoles were designed to be a direct replacement for the old ones and utilize the same electrical connections.

In most cases, new cables were not required and old ones were rerouted. All electrical cables reach the bridge deck at a central location near the aft bulkhead. Most rerouting involved moving cables closer to this central position.

Over the years, the installation of new equipment, the replacement of others, and the removal of obsolete units left the emergency power distribution in a severe condition of imbalance. In one case, three communications radios were connected to the same distribution breaker. Failure of this breaker would have disabled radio communications. Thus, the power distribution (emergency and domestic) on the bridge was the subject of careful rearrangement. Special care was taken to connect individual components to single breakers, giving priority to important components such as the HF radio or the echo sounders. In cases where more than one component was connected onto one distribution breaker, different functional components were chosen to enhance redundancy. In addition, emergency power and domestic power cables were distributed evenly throughout the bridge, making both power sources available in almost every location.

In consideration of the research role of the vessel, extra cabling of different types was added throughout the bridge to facilitate future implementations. The type, quantity and location of extra cabling was determined by evaluating present and future usage.

Certain assumptions were made about future requirements:

* Future applications will not likely require the transmission of large amounts of power. Therefore, power requirements will most likely be met by the existing power distribution throughout the bridge.

* Future applications will require multiple signal cables of low frequency bandwidth, or few cables of high frequency bandwidth capability, or both.

* Where insufficient quantities of extra cabling of a certain type will have been installed, multiplexing low frequency signals on a high frequency cable can be considered as an alternative.

* The use of intelligent communicating elements to transfer information will reduce signal transmission requirements in most cases.

* If an application is so stringent in communications requirements that existing cabling will not be sufficient, then it is most likely that the specialty of this application will comprise budget elements to cover such requirements.

Based on these considerations, four types of cables were used for the extra cabling:

- 75 Ohms RG59/u coax cable (high frequency requirements)
- 50 Ohms RG8/u coax cable (high frequency requirements)
- 6 core #20 shielded cable (med. freq. serial comm.)
- 25 core #20 shielded cable (low freq. control/signal)

Drawing # 63-E-80 shows the bridge interconsole cabling diagram. In the distribution of extra cabling, the SINSS console was considered the focal point. Therefore, most cables were routed to or from it, with few extra cables between other consoles.

3.8 Wing Console Information Display System

The display of navigation information at the wing conning positions is partially handled by colour monitors mounted in the wing consoles. These monitors present information that is either not displayed by conventional gauges on the wing consoles, or information such as rudder angle histograms (discussed in section 3.8.2) that could not be handled by conventional display technology. The necessary introduction of a computer to drive the wing console monitors, creates new possibilities in the area of navigation information processing. As information display requirements evolve or become better defined, the display system can be easily adapted through simple reprogramming.

The information to be displayed can be divided into three different groups, relating to the three operating modes of the vessel:

- Ice Navigation
- Open Water Navigation
- Manoeuvring

One page of information was created for each operating mode. Each page is called in turn by pressing a button adjacent to the wing console monitor. Each page has been designed to display the information in order of priority; important information occupying more display space in a more prominent location.

Information displayed on each page is received from the vessel's instrumentation system called "Vessel Safety and Performance Monitoring System" (VSPMS). The VSPMS collects data such as engine speed, propeller pitch, shaft torque etc., and displays the analyzed information on a monitor located on the bridge. One of the tasks of implementing the wing console display system, was to interface the

display computer to the VSPMS through the IEEE-488 interface it uses. This involved modifying the VSPMS software and the production of interface software for the wing console information display system. Further details on the VSPMS system can be found in Appendix D.

The display computer was chosen to be a 80286 IBM/AT compatible machine running at 10 Mhz and fitted with a 80287 math. coprocessor and a VGA card. Development of the driving software was done in the "Microsoft C" language.

3.8.1 Ice Navigation Page

This page provides information on the operational status of the propulsion plant, and the environmental conditions that can affect the ship's performance in ice. The following information is displayed (Figure 11):

1) Relative wind speed and direction
   Helps the navigator predict the level of wind induced ice pressure while manoeuvring.

2) Time and date
   Provided for convenient reference.

3) Heading
   Helps monitor gradual changes in ships direction.

4) Ice log and Doppler log
   The presence of both provides a better estimate of the ship's speed. One is generally valid while the other is false.

5) Shaft power
   Helps evaluate the amount of engine power available for manoeuvres.

6) Shaft thrust
Provides an indication of the effectiveness of the propulsion system. Pitch and RPM can ultimately be adjusted to deliver the most thrust for a given power output.

7) Rudder torque
Helps alert the navigating officers to the potential for damage to the rudder while backing up in ice.

3.8.2 Open Water Navigation Page

This page displays information required for long term performance evaluation and adjustments. Displayed variables are typically the result of calculations made over a period of 20 minutes that often involve up to three other variables. Most of the information on this page is displayed in numerical format, indicating the quantitative nature of the information. The Open Water Page contains the following (Figure 12):

1) Time and Date
Supplied for convenient reference.

2) Heading
Supplied for convenient reference.

Figure 11: Ice Navigation Page

Figure 12: Open Water Navigation Page

3) Relative Wind

Average wind direction and speed, averaged for a period of 10 minutes on a continuous basis. This information is more useful than instantaneous values when the vessel is on a steady course at a given speed.

4) True Wind

The true average wind direction and speed are calculated from the relative wind averages and the average ship's speed and course calculated over the same period.

5) Rudder angle Histogram

A histogram of the rudder angle values for the last 20 minutes is calculated and displayed in graphical format. These calculations are made to evaluate energy losses associated with rudder movements. Every time the rudder deviates from the centre line of the ship, it uses part of the propulsion energy to correct the ship's course.

The extent to which the rudder movements interfere with the ship's advance, is dependant on the amplitude of the rudder movements and the frequency at which course corrections are made. There is a cost associated with keeping a tightly controlled ship's heading. In some cases, if the gyro pilot is poorly adjusted, the energy expenditures lost to rudder movements can reduce the ship's speed by as much as 3 knots (20%). The rudder movement histogram assists the navigator in evaluating the extent and patterns of rudder movements.

6) Ship's Heading Histogram

A histogram of the ship's heading values for the last 20 minutes is calculated and displayed in graphical format. Since the heading can take any value from 0° to 360° the histogram is calculated to be centred around the 20 minute average of the

heading. The histogram will typically be bell shaped, with the centre of the bell coinciding with the average heading. When displayed on the screen, the histogram is referenced to the 10 minute average of the heading. Any change in heading will be noticeable from the histogram bell shifted to either side of the graph centre.

Used in combination with the heading histogram, this display allows the navigator to evaluate the effectiveness of the Gyro Pilot adjustments. Wider rudder angles will keep a tighter course at the expense of reduced speed and increased operating costs. The displays facilitate the monitoring of the rudder/heading interactions and assist with making the appropriate adjustments.

7) Shaft Power
This value is calculated from the RPM and torque of the main shaft and helps to adjust the pitch/RPM relationship for best performance in open water.

8) Engine Efficiency
This value is calculated from the engine RPMs, the fuel rack position, the calculated shaft power and the estimated fuel calorific value. The results are displayed in percent and assist with adjustments to the pitch/RPM relationship.

9) Fuel Consumption
This is the estimated fuel consumption from the fuel rack position and engine RPMs. The result is displayed in Tons/day and can be used to set the engine output.

10) Accumulated Fuel Consumption

The accumulated fuel consumption for a displayed elapsed time. This value can be very useful when weather conditions do not permit accurate soundings and consequently, fuel consumption calculations.

11) Average Ship Speed

An average of the ship's speed log is calculated for a period of 10 minutes. The results are used for true wind calculations and also displayed for convenient reference.

3.8.3 **Manoeuvring Page**

The manoeuvring page has a primary function of displaying immediate conditions, and the information needed for very short term planning. The parameters chosen for display are those that directly affect the manoeuvring condition of the ship, or otherwise influence its behaviour. The following parameters were chosen for display (Figure 13):

1) Date and Time

Provided for convenient reference but can be of value in case of accident, where event time is crucial.

2) Ship's Heading

Heading is of prime importance when manoeuvring. In conditions where visibility is impaired, the heading is the only frame of reference available.

Figure 13: Manoeuvring Page

3) Shaft Power

The engine power display is used to determine the engine output level, and the available power output margin. This display also gives the navigator an additional indication of the propulsion plant operational condition.

4) Ship's Speed

The ship's speed is necessary to provide an indication of the ship's advance in the absence of visual references, or when atmospheric conditions make it impossible to visually evaluate the ship speed. This display also helps to evaluate water current velocity when the ship is stationary.

5) Rate of Turn

When navigating in close quarters, and specifically in seaways, the ship's rate of turn can be crucial. The relative turning rate depends on wind direction and speed, water current speed, ship's speed, ship's draught, and rudder angle. Rapid fluctuations of these variables make it very difficult to predict the ship's behaviour at any one time. The rate of turn therefore provides a visual indication of the ship's behaviour.

6) Relative Wind

The wind speed and direction are required to provide an estimate of the manoeuvrability of the vessel in close quarters. The wind effect can be such that a certain manoeuvre cannot be made and assistance or avoidance may be required.

4. Implementation

Seven contractors were used for the implementation of the SINSS consoles and bridge design:

1) Canal Contractors of St. Catharines Ont., were contracted to build all navigation consoles.

2) Hammond Manufacturing Company Limited of Guelph Ont., were contracted to supply SINSS console components and fabricate the special console components needed for it.

3) Claude Bourque of Ottawa, was contracted to develop the software for the wing console display system.

4) Metricomp of Calgary, was contracted to provide assistance in modifying the VSPMS system software.

5) Lauzon Lavertu of Drummondville Qué., was contracted to design and build the main console digital display interface.

6) Baisley Richer Airfreight of Ottawa Ont., were contracted to ship the material to the drydock location.

7) Malta Drydocks of Malta, were contracted for the implementation of the bridge design and SINSS console installation.

4.1 Shipyard Selection

The nature of the bridge upgrade work would require a complete withdrawal of the vessel from service. In isolation this was not commercially justified and a decision was taken to combine it with a scheduled repair period.

Accordingly, a consolidated bridge upgrade/general repair specification was circulated to a number of repair yards in November. They were invited to bid for the work to be carried out in January/February 1989. Bids were processed during December and a firm commitment fixed with Malta Drydocks before Christmas.

The choice of repair yard entailed a number of considerations:

A) Overall price: The complete specification attracted a wide range of bids with the bridge content comprising 22-26% of the whole, (one bid at 9% was discarded because of excessive exclusions). Within the overall price, the bridge upgrade comprised one element. The eventual choice was made on the validity of the prices quoted against individual items within the specification.

B) Overall Time: This was solely determined by the bridge upgrade work. All bidders fell within a range of 14-18 running days.

C) Availability of Skills: This was significant for the bridge upgrade with its very high content of light engineering and finishing trade input.

D) Weather and Dock Availability: This was not really applicable for the bridge upgrade but a major determinant in terms of the complete specification.

The final choice of Malta Drydocks was based on their low price bid with 16 days required to complete the work. Their reputation in conversion and refurbishment work is good and in terms of weather, Malta represented the best that could be found in Europe in the early months of the year.

In the final analysis, the price for the bridge upgrade was 12% over quotation, however this margin was considered acceptable in view of the complexity and diversity of the work done. In terms of the overall repair period price, the bridge upgrade eventually represented 15% of the total due to changes in part of the repair specification by Canarctic. In terms of time in the dockyard the bridge upgrade remained the controlling item.

4.2 Material Shipment

Three shipments were sent to Malta:

1) The consoles with the majority of components, most of the cabling and the most recent drawings left Canada on January 6th, 1989, and arrived on the ship on January 24th, 1989.

2) The remainder of the cabling, the main console special interface, documentation from Canarctic, computer software, various components of the navigation consoles, and the WCD computer system left Canada on January 20th, 1989, and arrived in Malta on January 29th, 1989.

3) A radio HF antenna from Guelph Ontario left Canada on January 20th, 1989, and arrived in Malta in early February.

The bridge consoles were shipped in individual crates whereas the SINSS console was divided into modules to be assembled on site. The modules were crated in pairs, in a similar fashion as the main consoles. All components such as panels, fastening hardware and other items were shipped inside the SINSS console modules to reduce shipment volume.

Difficulties were encountered shipping the consoles to Malta. The shipment was loaded on an aircraft bound for Rome, Italy. Several days were lost in Rome while attempting to clear the shipment through customs. Having cleared the shipment, it was found that no aircraft scheduled to leave for Malta in the near future, had the capacity to handle the shipment because of its size. Consequently, the shipment was loaded in a container and shipped by land to a port in southern Italy, where it was loaded on a ship for Malta.

Several days were lost waiting for another shipment to complete the ship's cargo. Engine problems then forced the cargo ship to return to the Italian port, resulting in yet further delays.

The shipment finally reached Malta almost three weeks after leaving Canada. Similar problems were encountered for all shipments that were routed through Italy. Most shipments arrived with a minimum of a one week delay in excess of the time required for similar distances.

4.3 Bridge Implementation

The M.V. Arctic entered drydock on January 20th, 1989, one week behind schedule because of delays in leaving Italy. It was re-positioned along the dock on February 2nd, 1989, where it remained until February 8th, 1989. This delay in the vessel's arrival to Malta helped to offset the full impact of the delays with the console shipment.

However, the final version of the console drawings was also shipped with the consoles. Since the new drawings were not available from the start, all wires and connections removed from the old consoles had to be tagged and recorded, thus increasing somewhat the time required to complete the implementation.

No major technical problems were encountered during the implementation and most systems were found to be functional on first trial. Some trimming of console openings was necessary to fit reused components from the old console, since precise dimensions of these components were not available to the builder at the time of fabrication. Some modifications to certain circuits were necessary to match new circuitry with modified and undocumented old circuitry. In most cases, these were minor modifications, implemented in a matter of hours.

The SINSS console base was found to be too high and was reduced in height by 6 inches. Installation proceeded without major problems, although a lack of adequate documentation to help in the assembly of the Hammond rack modules made this job more time consuming. The installation of the SINSS console was limited to the base, console modules, front desk and viewing monitors during the yard period. The assembly of the console was completed in transit by the Canarctic Project Engineer after the M.V. Arctic departed Malta.

The pantry area, SINSS area (excluding the console), and chart table were designed and implemented on site. The requirements and complexity of these items did not necessitate extensive planning, and it was believed that the their implementation would be best handled by specifying the requirements and general dimensions to the carpenters who then proceeded to fabricate the required furniture.

Figures 14 through 21, present some examples of the bridge before and after the implementation. In addition, a single copy of a complete record of the implementation has been produced in colour slide format and was released with this report.

Figure 14: Old Chart Table

Figure 15: Old SINSS Console

Figure 16: Old Pantry Area

Figure 17: New Chart Table

Figure 18: New SINSS Console

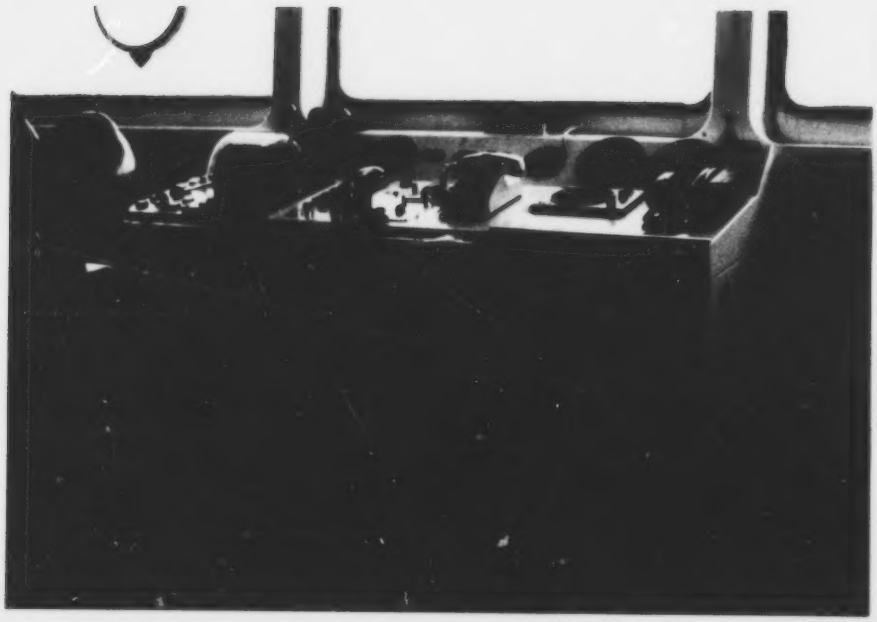


Figure 19: New Main Console

Figure 20: New Bridge Front

Figure 21: New Pantry Area

4.4 Wing Console Information Display System

The implementation of this system comprised two distinct components:

- Modifications to the VSPMS system to generate and transfer the required data to the wing display computer system
- Production of software to drive the wing display computer

4.4.1 VSPMS Software Modifications

A complete description of the VSPMS system as well as the difficulties associated with the modifications of the software is given in Appendix D. Most notable from this description is the fact that the software upgrades could not be implemented as originally planned. Problems with Hewlett Packard software, prevented the translation of the BASIC VSPMS program to a faster PASCAL version. Instead, special code was included in the existing VSPMS software to allow transmission of the required data to the wing console display system.

Calculations for engine power and fuel consumption are based on the multiplication of two or more variables. Since the data transmitted from the instrumentation system is averaged over a period of 1.5 seconds, rapid changes such as experienced during manoeuvres, will not be accurately represented. The averaging process acts as a filter, removing high frequency contents from the transmitted signals. Only signals changing slower than 5% per second will be represented accurately.

Calculations of this type are only required for the open water page which is used mainly during open water transits, during which conditions are fairly stable. Therefore, the information displayed using the average values transmitted by the VSPMS system will be accurate most of the time. Only occasionally will rapidly changing conditions be detrimental to accuracy.

4.4.2 Display System Implementation

Most of the software development for this system was relatively straight forward and no major problems were experienced. However, the development of an IEEE-488 interface software module met with some difficulty.

A standard GPIB (same standard as IEEE-488) interface card for the IBM PC computer was purchased to implement the communication link between the wing display system and the VSPMS. Preliminary trials were made in the Canarctic office to ensure compatibility with the Hewlett Packard instrumentation system. Tests were conclusive and development of the driving software, considered trivial at that point, was postponed until the upgrade period.

Even though the interface operated properly, difficulties were experienced dealing with the non standard Hewlett Packard interface protocol. Insufficient or missing documentation from the interface card manufacturer deferred all attempts at solving the problem until adequate documentation could be obtained. After obtaining sufficient documentation, a second visit to the ship was made and the interface to the VSPMS system was completed. The program was tested using simulation routines at different levels, and proven to operate reliably.

The computer system was installed on the bridge of the M.V. Arctic, at the back of the wheelhouse, in the research area. Video buffers were designed and built to drive the port and starboard wing console monitors. The system was tested and found to operate satisfactorily.

5. Conclusions

The new bridge design is much better suited for Arctic navigation and operations. More room has been liberated at the front of the bridge by the reduction in size of the consoles. Front windows are now accessible throughout the bridge front.

Furthermore, the console width reduction allows better access to windows located behind consoles. The chart table height reduction allows a clear view across the bridge in this area. A number of improvements to the layout of equipment and instruments, provide a more efficient and pleasant environment to work in.

The new consoles present a clear, uniform, and modern looking appearance. The navigators quickly became familiar with the new layout and commented positively on the new facilities. Based on these comments, it would appear that the most welcome improvements are those noted below:

- The chart table instrument layout presents a significant improvement to the old one. Information was grouped functionally on the instrument panel. The instrument panel face was brought forward towards the operator. Instruments that were previously difficult to reach, are now easily accessible at arms length. The working surface of the table has been increased. The top of the instrument panel has been lowered, providing a clear view across the bridge.

- The coffee area now contains the necessary facilities. It is no longer necessary to get water from the adjoining room, and the area is provided with a sink.

- All the windows are accessible at the front of the wheelhouse. Two windows were not available behind the old main navigation console. The reduced size of the main console provided access to two more windows on either side of it. The reduced width of all the consoles allows better access to windows located behind consoles.

- The consoles are now equipped with a slanted instrument panel, providing a clearer view of indicators from a further distance than before.

The SINSS console is quite massive in appearance, yet does not occupy an excessive amount of space. Easy access is available around the console, without interference from any other piece of equipment. The new R/D area includes a large working space, suitable for ice operations and research projects.

Sufficient cable redundancy has been incorporated in the interconsole cabling, to serve the needs of most research projects. The spare cabling covers a broad spectrum of types and sizes which should serve most future needs. When cabling redundancy becomes insufficient, multiplexing can be used to carry signals through a reduced number of conductors.

In general, the workmanship of the Malta drydock workers was found satisfactory. The work was of good quality and of a high technical level. Malta drydocks completed the work within their quoted period. There were no major incidents or corrections to be made after the completion of the docking period. However, as with many major development projects, there were several areas where problems did occur.

The duration and cost of the bridge upgrade was underestimated and the causes of the inaccurate estimate were multiple:

- Estimate of installation costs did not take into account the numerous trades required to complete the work in a shipyard environment. The quotes received from the different contractors varied considerably in range and reflect the uncertain nature of the task at hand.

- Difficulties in freighting the material were impossible to predict. Original quotes were difficult to obtain since the size and weight of the shipment was not known in advance.

- Software development was a formidable task. The difficulties were created by a chronic lack of documentation which suppliers failed to supply, inadequate software and hardware not operating as advertised. These problems created additional work that had not been budgeted for in the original proposal.

- The vessel was delayed getting into drydock, causing the implementation to begin later than planned. The Canarctic personnel waited one week on-site for the vessel's arrival, increasing the personnel costs of the project.

Transportation problems could possibly have been avoided if more time had been available. The short time available for the completion of the project imposed constraints on the choice of carrier and the delivery schedule. However, a good part of the freighting problems were caused by difficulties shipping through Italy. Transport strikes, bureaucracy, and other factors delayed the delivery of the equipment. The problems encountered in Italy could not have been foreseen and thereby avoided.

Numerous problems were experienced with the wing console display development phase of the project. It was disconcerting to discover the lack of technical support offered for the majority of products on the market today. In hindsight, the approach to the implementation of the wing display system was sound. A lack of documentation prevailed for all the software and hardware purchased for this project.

The majority of problems were caused by hardware or software that did not perform as stated in the documentation. Substantial time was lost searching for errors that were essentially the manufacturers fault to begin with. This state of affairs is apparently the hallmark of the IBM PC environment. Clearly, developments undertaken in the PC environment will always be fraught with the same kind of problems.

6. Recommendations

The design of the new bridge and SINSS console, is based on years of experience in ice navigation using different prototypes and operating procedures. For the first time, a bridge environment has been designed and implemented to investigate new technologies and procedures related specifically to ice navigation. The suitability of the new environment for ice navigation has, as yet, not been demonstrated.

The full extent of operational benefits gained from the new bridge configuration should be investigated both from a general perspective and in the frame of ice navigation. A dedicated study of the ergonomics of the new bridge environment would yield this information and such a study should be made relatively soon, before the effects of novelty on the operating personnel have faded.

The availability of an information display system in the wing consoles provides the means to test new information presentation techniques directly related to ice navigation. Information representing meaningful statistics about recent ship's performance may help the navigator evaluate one manoeuvring technique in relation to another. A study of the types of information that could achieve such goals should be made.

References

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3) Canarctic Shipping Company Ltd., (1988) SINSS Navigation Console Re-Design Phase I: Final Production Design Package Report for the Transportation Development Centre. TP-4428

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Appendix D
Vessel Safety and Performance Monitoring System

1.0 Instrumentation Upgrade

The hull of the M.V. Arctic was upgraded to an Arctic Ice class four (equivalent) in the spring of 1986 when the steel in the mid body was upgraded and the bow of the vessel was replaced by a new design. The stern of the vessel was not upgraded at that time. The ship was required to be equipped with a stern monitoring facility as part of a comprehensive instrumentation system to respond to Canadian Coast Guard safety requirements.

The original intent of the Vessel Safety and Performance Monitoring System (VSPMS) was strictly to monitor hull stresses, record excessive stress events, and display such events on a monitor located on the bridge. During the design of the system, several sensors and facilities were added to complete the system and make it more useful. The addition of propulsion and environment sensors provided data that was necessary for correlating the recorded events. Unfortunately, the new functions and facilities were not part of the original specifications. As a result, only limited resources were available for the implementation of these additions, even though they were recognised as necessary. The resulting implementation was somewhat crude but performed the necessary tasks. The user interface of the system, however, is limited. The execution of functions other than the elementary operations require a working knowledge of the Hewlett Packard Basic Operating System.

The system was implemented on a Hewlett Packard series 9000 computer system. The basic configuration includes the following (Fig. D-1):

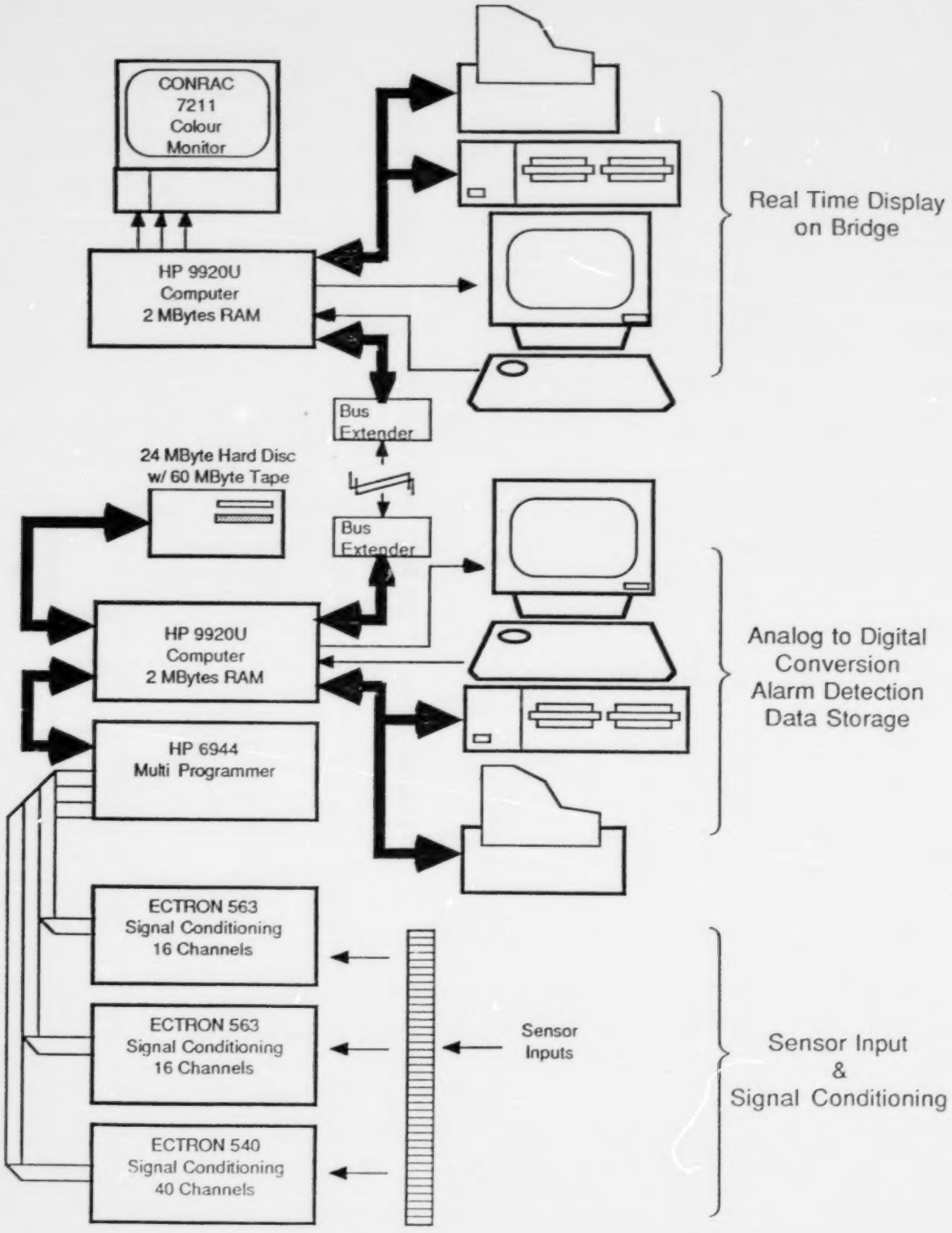

Figure D-1

VSPMS system block diagram

- A signal conditioning amplifier rack. This amplifier bank translates the weak electrical signals received from the various sensors, into electrical levels that can be managed by the data acquisition module of the computer system. A total of 68 conditioning amplifiers are included in the amplifier rack.

- A signal multiplexer (called a Multiprogrammer) sequentially connects the data acquisition module to each data signal. A total of 256 channels can be connected to the multiplexer input.

- A data acquisition module converts the electrical signals into digital format. The module converts the signal into a 10 bit binary word that allows a range of +/- 1024 discrete levels. The input signal allowable voltage range is +/- 10 volts. The input signal can thus be discriminated with a resolution of 10 mVolts. Combined with the signal multiplexer, the data acquisition module can digitize 100 samples per channel per second.

- A dual floppy disk drive, for temporary data storage, and system boot-up sequence.

- A hard disk/tape backup unit for mass storage of recorded data. The disk unit has 24 Mbytes of storage capacity and is capable of approximately 7 minutes of continuous data storage. For each recorded event, a total of 15 seconds of data are recorded for all 256 available channels. In this way, 28 events can be recorded on the hard disk before a tape backup is required. A total of 3 backups can be performed on one backup tape.

- A computer system located on the bridge of the M.V. Arctic, used to display the collected data in graphical form. The bridge computer is also used to control the functions of the system. This computer is connected to another similar computer located in the laboratory. The connection is made through a HP-IB (IEEE-488) bus extender. A colour monitor is connected to the bridge computer for display purposes.

- A computer system, located in the laboratory, to analyze and process the collected data. The computer system coordinates the actions of the multiprogrammer and the data acquisition module. It also handles data interface with the bridge computer, the floppy disk unit, the hard disk unit, and the tape backup unit.

- Three programs have been written to drive the hardware package. One program (DISP_GEN) operates on the bridge computer and displays data in graphical format. Another program (SCAN) operates on the laboratory computer and is responsible for data acquisition. The third program (UTILITIES) can be operated on the bridge computer or the lab. computer. This program is used to retrieve recorded data or edit the system configuration file.

1.1 Modification Specifications

The primary purpose behind modifications to the instrumentation system was to provide the Wing Console Information Display computer (WCID) computer with the data required for the navigation display pages.

Most of the data required by the WCD computer is already available from the instrumentation system, with the exception of data that relies on special calculations not performed on the present instrumentation system. The following paragraphs describe the nature of these special calculations.

The data is output from the VSPMS system every 1.5 seconds and is presented in the form of an average for that period (representing a total of 150 values). The shaft power is calculated by multiplying the shaft torque by the shaft speed. Similarly, a value proportional to fuel consumption is obtained by the multiplication of the fuel rack reading with the engine RPMs. The true value of the shaft power or the fuel consumption cannot be obtained from the product of the average shaft torque and the average shaft RPM. It is a well known mathematical principle that the average of a product is not equal to the product of averages. To obtain the true average power, each torque and RPM readings (100 times per second) must be multiplied and then the value of the product averaged, a process not implemented on the present system.

If the engine is running at near constant RPM and power output, power calculations based on a 1.5 second average of the shaft torque and RPM would be sufficiently accurate. However, while manoeuvring in ice, the engine rapidly cycles through full power to idle condition in typically less than 5 or 6 seconds. In these conditions, every data update will represent a 25% change in power output, and the average power calculated from the 1.5 second update would not be accurate and true averages would be needed. For display purposes, the values would be acceptable, but fuel consumption and efficiency calculations demand more accuracy.

The same principle applies to any data that must be calculated from other primary variables. An example of this is the calculation of the ship's heading from the SINE and COSINE values available from the gyro. Again, the average heading is not equal to the angle derived from the averages of the SINE and COSINE.

Modifications must be made to the system instrumentation software to allow the calculations of real time averages of composite variables. Real time composite averages would be called pseudo channels. Pseudo channels would behave like real data channels to the user, but would be created artificially.

The instrumentation system software has been written in Basic and at the present moment the execution of the program occupies 95% of the computer processing time. To implement pseudo channels, more processing time must be available. To free processing time, the main program must be translated in Pascal, which is a compiled language as opposed to the Basic language. Since Pascal allows a ten fold increase in speed, ample processing time would be left to implement such features as pseudo channels.

The translation of the Basic software into Pascal entails the total rewriting of the program. Features of Basic cannot be implemented directly in Pascal and conversely, some features of Pascal will simplify their Basic equivalent. If the software is to be rewritten, it is a simple matter to correct deficiencies and add features that are considered useful or essential. It was thus considered cost effective to combine the two goals in the same project:

- Modify the software to generate the required data (pseudo channels)

- Modify the software to eliminate defects and implement new functions not included when the system was originally designed

To maintain functional compatibility with the old system, the process of converting the Basic software in Pascal began by the identification of the present system functions. The system functions were identified, both at the software level and the operational level, and are summarized below:

- All channels are scanned continuously and compared to the alarm limit for that particular channel. If the alarm limit is exceeded, all 256 channels are recorded simultaneously on the hard disk. Five seconds of pre-alarm data (recorded in a buffer at all times), and ten seconds of post-alarm data is recorded on the disk. For each event, the alarm channel number and the time (date included) are recorded with the data. If so required, data storage can be triggered manually for indefinite periods, up to the storage limit of the hard disk. Histogram data can be recorded as specified by the user in a system configuration file.

- Four data display modes are available for the bridge display. The first mode displays hull stress information in a bar graph format. This bar graph is available for open water condition or sheltered water condition. The second mode displays two channels in time graphical format, with update every 1.5 seconds. The displayed channels can be selected from the bridge computer system through menu options. The third mode displays an alarm page to the monitor in case of an alarm condition. This alarm page shows the alarm location and intensity. No audible signal is emitted in case of alarm. The fourth

mode displays a system status page on the bridge and laboratory monochrome monitors. The system status page displays information about time, communications status, disk storage status, and other important data. All bridge colour monitor displays can be output to the monochrome monitor, thus providing redundancy.

- A system configuration file (CONFIG file) contains a list of all sensors connected to the system. For each sensor, the calibration factors and signal offsets are specified. This data is used by the system to process the incoming data. The configuration file also contains all the histogram storage specifications. A copy of this file is kept on the bridge and the lab computer. This file is necessary on both systems, because the data is recorded and transferred in digital counts. The conversion of digital counts to real values, necessitates the availability of the CONFIG file.

- A utility program is available to perform data retrieval and configuration file editing. This program can generate graphics of recorded data and allows the user to scale graphics to the desired size. The utility program is the only means of extracting recorded data from the instrumentation system. The configuration file needs to be edited from time to time, to reflect changes in sensor characteristics, or simply for calibration purposes.

- Menu selections allow the user to perform certain functions such as change the date and time, or select the data display mode. Apart from these functions, very limited operations are permitted from the main program control menu.

The pseudo channels facility was to be implemented in assembly language. The necessary changes to the remaining program were to be made in Pascal.

Experience in operating the instrumentation system had clearly identified deficiencies and the following additional functions were considered necessary:

1) Add Calibration Routine:
   The signal conditioning amplifier rack has an input that allows an artificial "data step" of known value to be created. This step feature allows quick and easy calibration of the amplifiers and analog to digital conversion unit. At the present moment, the only way to verify the recorded value of the calibration step, is to use the UTILITY program. The UTILITY program is very time consuming to use and only provides output data in graphical format. To take full advantage of the precision of the instrumentation system for the calibration procedure, the output data should be in numerical format. The data would be output in the form of a table containing the necessary channel identification and the corresponding data step in numerical format. The recorded step could then be used to either correct the amplifier gain or change the calibration factors in the configuration file as required.

2) Two Wave Forms on Lab. Computer:
   As previously described, two channels of real time data can be displayed on the bridge computer. These two channels can be selected either from the bridge or the Lab computer. However, the channel selection is performed differently from the bridge unit than it is from the Lab unit. The first change would be to standardize the way the waveform channel is selected from the different stations.

The waveform display is only available on the bridge unit. When system verifications are being made, or when dedicated studies are under way, substantial benefits would result from the display of the two real time waveforms on the Lab computer unit. The second change would be to implement this facility.

3) CONFIG File Update:

The system configuration file (CONFIG file), can be edited from the Lab unit or from the bridge unit. Once updated on either work station, the CONFIG file has to be transmitted to the other station. At the moment, the transfer is automatic if the system is started from cold and the bridge unit is started first.

If the modifications to the config file were made on the bridge unit and the system is restarted, the new file will be overwritten by the old file still resident on the Lab unit. The other way to transfer the config file is to take a disk copy to the other station and overwrite the old file. The program would be modified to allow transfer of the CONFIG file at any time from the main program, from any unit to the other.

4) Page Refresh:

Because of the operating mode of the Hewlett Packard computers, it is possible to write information on the display screen while a program is executing. The display disruptions can be such that the needed information is no longer visible. A refresh option should be available to return the display to original state.

5) Hard Disk Drive Flush:
If false alarms are generated by the system, the hard disk is quickly filled by false data to full capacity. Once the disk is full, subsequent data is dumped and valuable information will be lost if the hard disk is not emptied.

At the moment, the hard disk can only be emptied by making a backup of the data it contains. The backup routine automatically clears the disk at the end of a backup. An option should be added to clear the hard disk of data when this data is known to be false.

6) Access to Backed up Data from Floppy, Tape or Hard Drives:
Access to recorded data is very time consuming and complicated at the present moment. This operation definitely requires a working knowledge of the Hewlett Packard Basic Operating System. Access to recorded data should be made simpler and should be incorporated in the UTILITY program. This access utility should be implemented on a menu driven basis.

7) IBM Pc Data Transfer:
The recorded data on the instrumentation system is stored in Hewlett Packard special format. Research projects would benefit from the availability of Pc readable disks. Hewlett Packard equipment is expensive and is not widely used in an office environment. A data transfer routine should be implemented to send data to the WCD computer for recording on Pc compatible disks.

8) Audible Alarm Signal:
Alarms generated on the instrumentation system are only displayed on the bridge monitor. No audible signal is available to warn the operator that an alarm condition has

occurred. Some means of implementing an audible signal should be found and implemented. This audible signal should be complemented by an acknowledge button to cancel the alarm.

9) Multiple Correlation Histograms:
The histogram data recorded on the system is now unidimensional. In some cases, the availability of a second correlated histogram channel would be beneficial. One example would be the shaft thrust correlated with the ship's speed or propeller pitch. The feasibility of implementing multiple correlated histograms should be investigated.

10) Limited Event Recording:
Hewlett Packard equipment benefits from wide acceptance and international reputation. The experience on board the M.V. Arctic has been very disappointing and costly. Hard disk drive failures have been frequent and numerous problems have been experienced with other equipment supplied by Hewlett Packard. Very little customer support has been received and technical support outside very basic applications is non-existent.
Hard disk failure causes the main program to stop functioning and renders useless the whole instrumentation system. It is suggested that limited storage facilities be implemented with the auxiliary floppy drives, in case a hard disk failure occurs.

The functions described above are in addition to the primary purpose of this conversion. The primary purpose is to provide more speed to the main program in order to implement pseudo channel creation.

The Hewlett Packard company was consulted and a detailed description of the instrumentation system on the M.V. Arctic was given. The scope of the project was explained and a request was made for recommendations on rental equipment. A list was provided with the assurance of compatibility with the shipboard equipment.

The software engineer that originally developed the instrumentation software was contacted. A full description of the intended project and the scope of work was given. The merits and difficulties of the project were discussed and solutions were found for most difficulties. Recommendations on the course of action were received and acted upon.

1.2 Pascal Translation

The Basic programs were studied and the algorithms were extracted. Special features of the Basic language were studied to assist in the translation process. High level pseudo code for the programs was produced. The Hewlett Packard implementation of the Pascal language was studied and program translation was partially completed. The program listings for this translation were written on Pc compatible machines, in ASCII format.

The rental equipment was ordered and installed in the office. The Pascal Operating system was installed on the rental equipment and all attempts to get the software to function failed. After discussions with Hewlett Packard, they confirmed that the Pascal version (version 2.0) in our possession would not operate on the rental equipment. We were not informed of this fact during the initial discussions with Hewlett Packard. To continue developments, a newer version of Pascal was purchased (version 3.2) and installed successfully on the rental equipment.

The WCD computer (described further in this report) was used to load the translated code from Pc format to Hewlett Packard format. Many Pascal routines were tested and the translation was completed up to the multiprogrammer interface code. This code could not be tested since no multiprogrammer was available in the office. The original system software engineer was consulted on the question of interfacing to the multiprogrammer in Pascal.

A telefax of detailed instructions was sent, describing the different calling parameters and data exchange protocols. The instructions also described the driver files that should be used to interface to the unit.

Prior to the project, a copy of all the software resident on the vessel was made. The software copies were taken back to the office to be used in this project. The driver software for the multiprogrammer was omitted since it could not be found.

A request was made to Hewlett Packard to supply the Pascal compatible drivers. We were instructed at that point that Hewlett Packard did not support the multiprogrammer for Pascal operation. The same contact at HP that had supplied the rental equipment list, instructed us that it was not the company policy to support that unit for this programming environment.

The software for driving the multiprogrammer was originally developed by Hewlett Packard in the following way: a Pascal language driver was written and compiled to produce an executable file. The produced file was then converted by a utility program into a Basic callable driver program. Even though the Pascal compiled file is directly callable from any Pascal program, Hewlett Packard refused to supply them. These files exist, since they had to be produced to create the Basic callable drivers. To this day, Hewlett Packard will not release the Pascal object code

modules, contending it is not their policy to do so. Furthermore, HP indicated that the object code would be very difficult to locate should they ever decide to release it.

Faced with this problem, discussions with Hewlett Packard and the software engineering consultant, led to the conclusion that the only option left was to use Basic as a front end, and Pascal compiled modules callable from Basic to perform all the main program routines. Hewlett Packard expressed the concern that the Basic callable modules produced from Pascal, would not be compatible with the Basic version used on the ship. Internal inquiries on their part confirmed that the modules would be compatible.

The software was already written, and the task of converting the different routines to callable modules was deferred until the shipboard implementation. The conversion task was investigated and judged trivial. The remaining part of the time in office concentrated on developing the WCD computer software.

1.3 Shipboard Implementation

Upon arrival on the ship, the software drivers for the multiprogrammer were searched for in the hope that the object code would be available (Hewlett Packard were never positive about this point). As expected, the driver object code was not available. The Pascal operating system was installed and the Pascal conversion to callable modules began. After several days of segmenting the Pascal program to produce small callable modules, testing began. Multiple errors resulted from using the Pascal modules, indicating a serious problem with compatibility. Intensive review of the documentation revealed that only very elementary operations are permitted in a Basic callable Pascal

module. No library functions are available in this mode of operation. Most of the Pascal routine that needed conversion, contain library functions that cannot be used in the callable mode. Neither Hewlett Packard nor the original system software engineer gave any indication of this unfortunate fact. On the contrary, Hewlett Packard recommendations were to use this approach to solve the problem.

Subsequent to the above described events, the situation was as follows:

A) A program written completely in Pascal could not be used because the Multiprogrammer is not supported in that language.

B) An attempt was made at converting the Pascal routines in Basic callable format. Unfortunately, most functions are not supported in Pascal when used in the Basic callable format.

There was no option left but to abandon the program conversion and concentrate on transferring the required data to the WCD computer. To accomplish this, the bridge program (DISP_GEN) was modified to send the required data to the WCD computer. The transferred data will be adequate most of the time. The data will be of lesser quality when changes are significantly faster than the 1.5 seconds between updates. The functions to be added to the system could not be implemented because of a lack of processor time.

During software conversion, many errors were found in the main programs. The errors were causing occasional erratic behaviour of the main program that were previously unexplainable. These errors were corrected and the revised code tested.